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Environment for Development

Public Relations for Disasters Related to Climate Change in Thailand

Guidelines for Urban Spatial Development to mitigate the Urban Heat Island Effect in the Inner City Area of Bangkok

Management Guidelines for dredged sediment from Lumsai Canal and rice straw in Koiruttagwa Community, Nong Chok

Novel Non-Tracking Solar Panels for Process heating Applications

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Attachment and entrapment immobilization of cyanobacteria *Synechocystis* sp. cells using chitosan

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Editor's Note

Environmental pressures on our world are intensifying, with pollution and climate change causing extreme impacts, such as the increasing frequency and severity of extreme weather events and natural disasters. Our use of natural resources to drive economic development is no longer sustainable, and quality of life is degraded in both urban and rural areas through ecological destruction. It is therefore an urgent priority that we undertake research to develop knowledge and technologies in terms of planning, utilization, conservation and restoration of natural resources and enhancing the environment to achieve sustainability. Such research needs also to address the need for guidelines to protect, treat and rehabilitate environmental destruction, and mitigate its potential impact on humans and nature, as well as on economic development.

At present, research into risk management forecasting is bringing us new and effective technologies for planning and management of natural resources and environment, as well as increasingly rigorous risk management and mitigation tools based on a large body of scientific knowledge. These studies can be combined with social education to drive a paradigm shift among manufacturers and consumers towards sustainable and environmentally friendly patterns of production and consumption. Critical to success is the prioritization of environmental responsibility as a critical priority among policymakers, researchers and on an individual level. It is essential that all sectors join together to *"grow and raise awareness of environmental conservation"* and act together on their responsibilities towards our common environment.

The Editorial Board

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URBAN HEAT ISLAND

Guidelines for Urban Spatial Development to Mitigate the Urban Heat Island Effect in the Inner City Area of Bangkok

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Introduction

The Urban Heat Island (UHI) effect is a highly visible phenomenon that exacerbates the impacts of climate change. It is caused by a rise in temperature within a metropolitan area due to congestion of buildings, roads and buildings in urban landscapes, all of which generate excess heat. Radiation from a landscape comprising mostly roads and buildings, with few green areas and parks, also contributes to higher urban temperatures. Consequently, urban areas tend to exhibit significantly warmer temperatures than their surrounding rural areas.

As one of the world's major metropolitan cities, Bangkok has also been affected by UHI, especially in inner city areas. Hence, practical approaches are needed to mitigate UHI in Bangkok's urban landscape. A realistic approach will reduce average temperatures, while also enhancing the physical environment and quality of life, thus fostering investment in future city development.

As a result, the study of the relationship between urban physical environment and the change in temperature, which are the primary causes of UHI in the area, provided insights into shared physical characteristics in the inner city of Bangkok Metropolis- an important area for future residential and commercial development. The research findings contributed towards formulation of recommendations to mitigate or prevent UHIs in Bangkok's inner city.

https://en.wikipedia.org/wiki/Bangkok

Concept and rationale

Climate change is emerging as an existential crisis for all of humanity. The impacts continue to worsen drastically and metropolitan areas around the world report higher average temperatures (Oke, 1982; Gideon, 1995; Asimakopoulos, 2001). UHI is caused by physical differences in the reflectivity and heat absorption of urban landscapes, as well as emission of excess heat from vehicle exhausts, air conditioning and other human activities concentrated in the urban area. Climate change is known to exacerbate the UHI effect, which can increase temperatures by 5-8 °C (Tsangrassoulis et al., 2001) compared with surrounding peri-urban or rural areas.

Satellite data obtained from Landsat 5-TM Band 6 provided by the Geo-Informatics and Space Technology Development Agency (GISTDA) clearly captures the formation and expansion of UHIs in Bangkok's inner city. Time-series data show that UHIs form and expand following the course of development of the given urban area.

Given the high population density in Bangkok's inner city, it is important to understand the relationship between the urban physical environment and temperature changes as the main causes of UHI. Such insight will contribute to formulating measures to prevent or mitigate the impact of UHIs, while reducing its propensity to expand to surrounding urban areas.

Study of UHI in the inner city of Bangkok Metropolis

In the study of UHI in Bangkok's inner city, it is proposed that the solution can be found from the investigation of physical characteristics of the given urban area and its future development projects. This provides the following research methods framework as outlined below.

1. Study of the location, topography, climate, and other physical characteristics of the Bangkok Metropolis. This basic information was fundamental to establishing a benchmark and in quantifying impacts.

2. Analysis of the overall change in temperature in Bangkok using 10-year climatological data obtained from the Thai Meteorological Department

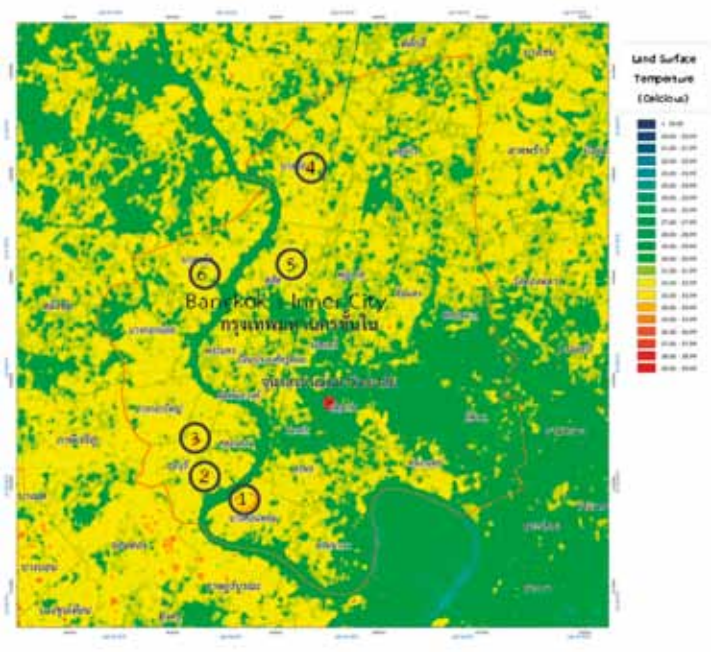

Figure 1 UHI Study Areas in Bangkok's Inner City at micro-level
Source: Geo-Informatics and Space Technology Development Agency (GISTDA) (2014)

(2002-2013). This study followed the emergence of UHIs in urban areas, and analyzed overall trends in surface temperature changes in Bangkok.

3. Collection and analysis of data from the study areas at micro-level, to observe changes that occurred according to the time and conditions relevant to UHI, and finally concluded the results of temperature changes. At this stage, six study areas were selected for micro-level analysis using remote sensing data. The study areas were communities in: 1) Rama 3 Road, Bang Kho Laem district; 2) Soi Charoennakorn 28, Thonburi district; 3) Soi Nai Loi Itsaraphap 15, Khlong San district; 4) Wongsawang Road, Soi 17; 5) Nakornchaisri Road, Dusit district; 6) Charansanitwong 63, Tang Hua Seng Thonburi district (see Figure 1).

Temperature data for the study areas were collected using at 5-minute intervals from one hour after sunset for 4 months during the winter season.

Results of the study of UHI in Bangkok's inner city

Analysis of data obtained from the Climatological Centre, Meteorological Development Bureau under the Thai Meteorological Department, confirmed that Bangkok's overall temperature has increased by at least 0.8 ℃ compared to average temperatures over the previous 30-year period (1971-2000). Remote sensing data also confirmed that the area at the heart of Bangkok has the highest density of buildings and construction. Over time, this dense urban spatial structure gradually expands into the adjacent surrounding areas.

It was found that average temperatures in Bangkok's inner city and surrounding areas reached as high as 28 ℃, compared with 23 ℃ in Bangkok's more agricultural eastern and western suburban areas (Nong Chok and Bang Khun Thian districts). A detailed analysis of temperature changes in Bangkok's inner city over the 20-year period from 1994-2003 found that surface temperatures have risen by an average 2 ℃; the increase is clearly correlated with the expansion of the urban landscape over the same period. However, during the following decade from 2004-2014, there has not been any significant change in physical characteristics of the soil surface in the inner city, hence the relatively stable surface temperature and minimal change at the macro level.

The results of temperature measurement taken one hour after sunset found that the identified UHI-affected areas show very minimal decrease in temperature as compared to surrounding areas, where night temperatures typically fall by 2.8 - 3.6 ℃ on average. The six study areas show average temperature drops of only 0.8-1.1 ℃ (Figures 2-7).

Conclusions

1. The majority of the buildings in the area are small scale buildings of similar heights which consist mostly of detached houses that are densely situated with narrow space between buildings. The construction materials are concrete, stone, and cement, with roof lined with tiles or steel sheets. Such built surfaces tend to absorb a significant proportion of the incident radiation. Consequently, areas with buildings at similar height can evenly absorb solar radiation all day. This results in a constant release of heat from the urban surface at night which can cover a wide perimeter. The large quantities of heat released can create severe heat build-up due to the storage of heat flux in central urban areas.

2. Without the presence of any high rise buildings, homogenous building height in the study areas creates a level plane in which buildings are equally exposed to sunlight all day. This is a distinctive feature that is different from other urban areas with high rise buildings that provide shade to the nearby

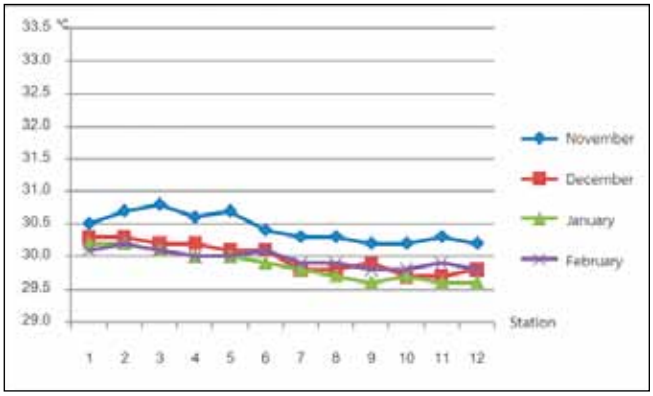

Figure 2 Change in Average Temperature in Charansanitwong
Source: Jittisak Thammapornpilas (2015)

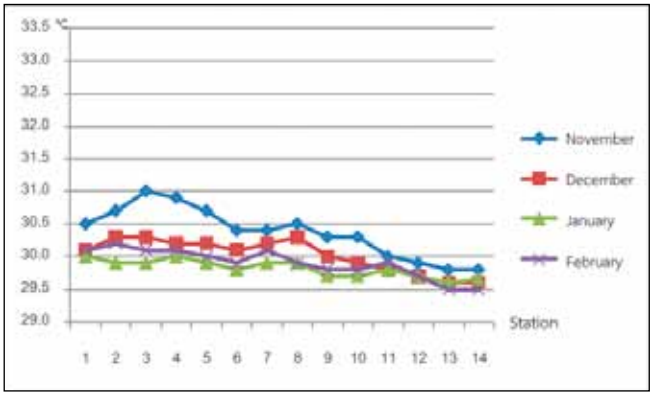

Figure 3 Change in Average Temperature in Dusit
Source: Jittisak Thammapornpilas (2015)

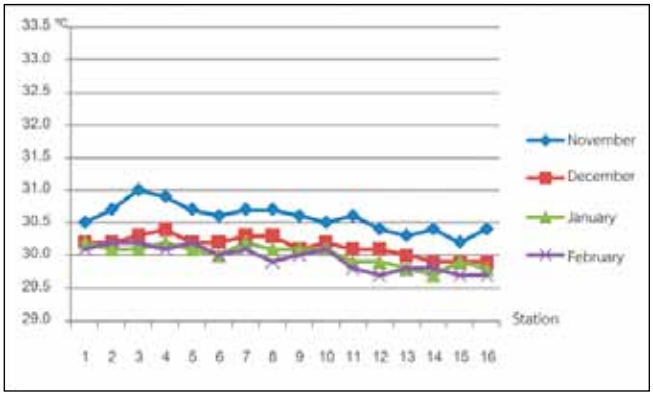

Figure 4 Change in Average Temperature in Bang Kho Laem
Source: Jittisak Thammapornpilas (2015)

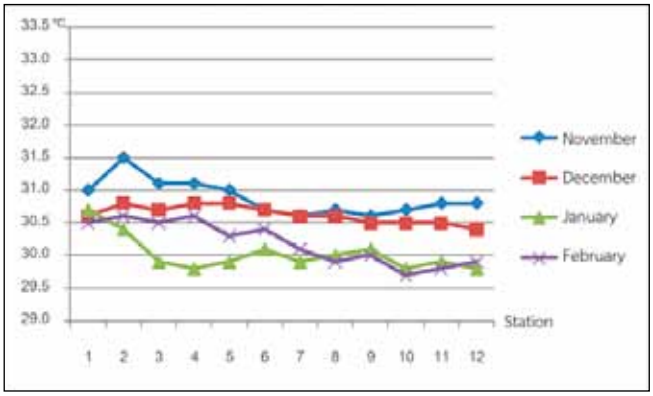

Figure 5 Change in Average Temperature in Wongsawang, Soi 17
Source: Jittisak Thammapornpilas (2015)

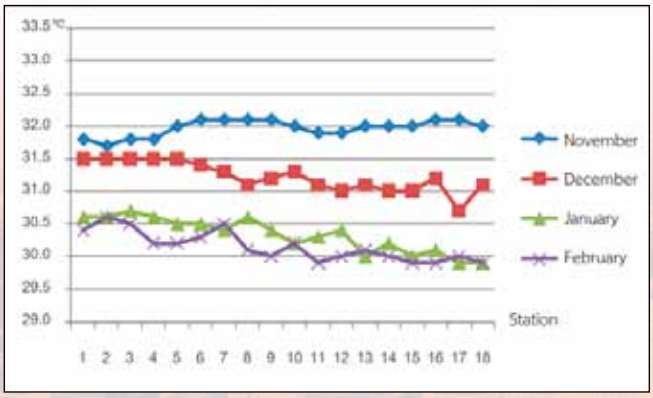

Figure 6 Change in Average Temperature in Khlong San, Soi Itsaraphap
Source: Jittisak Thammapornpilas (2015)

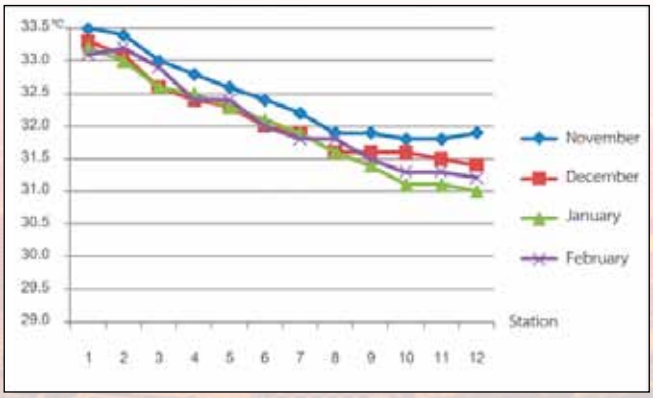

Figure 7 Change in Average Temperature in Charoennakorn
Source: Jittisak Thammapornpilas (2015)

construction and available space, hence uneven exposure to sunlight. Consequently, the amount of heat released from areas with heterogeneity in building heights will be remarkably less in quantity compared to their homogenous counterparts.

3. Only a limited amount of natural soil surfaces were found in the field survey of the study areas. Unlike unused lands with natural surface, the majority of vacant lands or areas surrounding buildings in the study areas are hardscapes whose surfaces absorb heat and prevent natural evaporation which contributes to cooling of the air.

4. The study area features a dense network of narrow, winding streets and cul-de-sacs; the dense arrangement of buildings on both sides of the streets impedes the flow of air and prevents flushing of heat build-up. Therefore, due to the fact that air tends to flow better through 'urban canyons', heat transfer from street areas is less efficient in the study areas.

5. There is a lack of large trees in the study areas. Vegetation is a critical factor that helps to moderate temperatures in urban areas. The process of photosynthesis creates atmospheric humidity, whilst evaporation also has a cooling effect. Moreover, vegetation does not absorb heat, and shade from trees also helps moderate temperatures.

Recommendations for improvement of urban physical characteristics

The results from the study of the shared physical characteristics of the sample UHI-affected areas offer insights into ways to improve urban physical characteristics in order to reduce the formation of UHI in the inner city of Bangkok Metropolis. The study's recommendations are as follows.

1. Construction of densely packed buildings of uniform heights should be avoided in the same area. Heterogeneity in building heights should be encouraged, with appropriate spatial distribution of high-rise buildings to create shade and ventilation to reduce heat accumulation. At the same time, high-rise or other large buildings and densely built structures should use surface materials with low heat-absorbing properties, such as perforated lightweight construction materials to reduce heat absorption and release.

2. Unnecessary hardscape should be minimized in urban areas. Wherever possible, original natural vegetation should be preserved to provide shade, increase visual amenity and allow natural evaporation to work effectively to reduce heat build-up.

3. Effective road network design is critical, focusing on appropriate lane widths to facilitate air flow hat will quickly dissipate heat from buildings and structures and reduce of the storage of heat flux.

4. Increasing green space, water sources and island planting in the city will contribute to moderating heat build-up in cities, and should be incorporated as far as possible in urban planning and design.

However, in order to solve problems in urban landscapes in the inner city of Bangkok Metropolis which has a long history of construction and development, collaboration and consensus must be achieved from all relevant stakeholders. This will be essential to ensure successful practical application of the recommendations emerging from this study.

Acknowledgements

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Public Relations for Disasters Related to Climate Change in Thailand

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Introduction

Our world is now facing environmental issues and crises as a result of climate change and global warming. Many countries have been suffering from natural disasters. Thailand is one of those countries affected by global warming and unpredictable natural phenomena such as tsunami hitting the Andaman coast of southern Thailand in 2004 and a tragic flood in 2011. These natural disasters affected people's lives dramatically and even caused casualties. However, in some incidents, the damage could have been prevented and victims could have been engaged with better if appropriate public relations institutions existed.

Given such a situation, the researcher is aware and concerned by the affected people in the disasters, and considers it necessary to have suitable time, type, means, and channels of public relations in place, both in traditional and new media, to educate people about the procedure in such emergency incidents. Clear, suitable, and consistent warning and cautions are mandatory to ensure the safety of the public, society, and community. This is because the means of public relations in each channel broadcast to the general public or the victims in the past was not standard and suitable. For example, there are always differences in broadcasting time, frequency, levels of language, sequence of presentation, method of presentation, and terminologies. A good example would be when free TV channels in Thailand reported a disaster at different times. They also presented data from different sources. Most of the time, the coverage did not actually cover the whole target area. There is also the issue of inappropriate registers. All these resulted in inaccurate information and confusion. As the public receives conflicting pieces of information, they are unsure on what sources to rely or who has the most accurate information.

The research titled *"Public Relations for Disasters Related to Climate Change in Thailand"* is all about investigating how to use media to provide information in disasters appropriately and effectively. The media in this research includes both traditional media like TV, radio, printed media, and outdoor media, and new media such as online media or social media. The research examines the patterns, methods, and channels of broadcasting pictures, messages, and signs to warn people in disaster events or how to do when floods, tsunamis, or earthquakes occur. Research methodology includes:

Part 1: Qualitative research

1. Study the documents about public relations in disaster events such as floods, tsunamis, and earthquakes

2. Have 3 focus groups discussions (6-8 persons each) consisting of males and females who have been informed and are expected to be informed of public relations to create understanding, change information, and find the procedure in disaster events

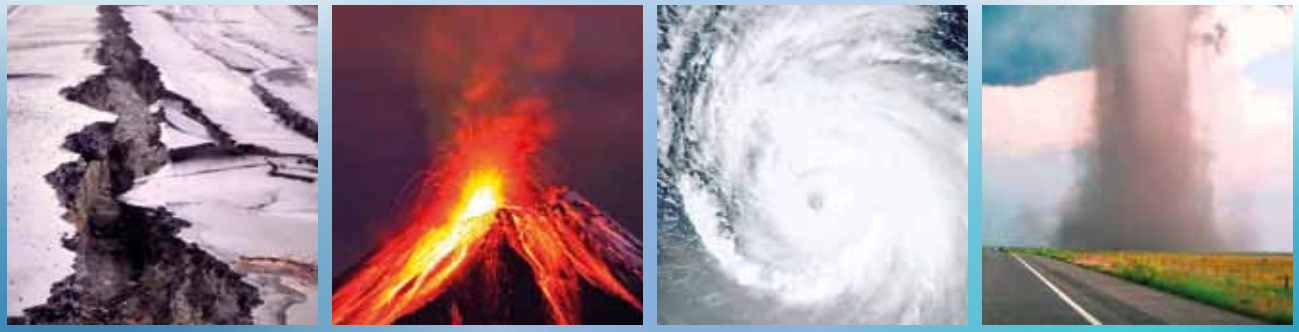
The first group consists of people who were affected by flood or people who provided relief in connection to the flood events in Bangkok or its surrounding areas.

The second group consists of people who were affected by tsunamis or people who provided relief in connection to the tsunami event in Phang-nga.

The third group consists of people who were affected by the earthquake or people who provided relief in connection to the earthquake event in Chiang Mai.

Part 2: Quantitative research

The quantitative research employs the survey approach. Data was collected by using a questionnaire. The researcher has established a research methodology to achieve the goal about how the 400 people who are affected by disasters received information in the tragic events that unfolded and about the effectiveness of the communication means.



Global Warming

Communication concepts about the risk of disaster

In the situation that people are at risk of disasters, one basic need is access to information. Upon receiving the warning about a disaster before it happens, people who are at risk are going to seek more information. They will try to find information from many sources in order to confirm its accuracy and validate its credibility (Mileti and Sorensen, 1990).

Approach to public relations on disasters

A good thing about public relations is when an unexpected event like a tornado takes place, a risk management plan could be useful to provide a real-time communication service to mitigate the disaster (Patty Norris Lubold, 2011 referenced in Jhudson, 2012). The following can be the procedure to follow in case of disasters:

1) It is important to respond to disaster occurred in the society even though it might not affect the businesses.

2) Do not do too much branding during the time of disaster.

3) Sympathy is key, giving priority to staff in organizations and society before the business itself.

4) The first thing is to communicate with people inside the organization to prevent information leak or distribution of adverse information to the society.

5) Consider which online media can be used as a tool for communication because not all disasters will get response from the society.

6) The organization shall take control of the direction and how the story is told.

7) The organization must make its staff and society believe that it is willing to have them as part of public relations.

Approach to use social media for public relations about disasters

Introduction of social media or the new media for public relations about disaster change the traditional communication considerably. In the past, communication was done from the top to the bottom (top-down communication). The information was told to the public only as they needed to know (Noam and Sato, 1996 referenced in Sung, 2011). With the new media, people have more access to information. Better accessibility paves the way to two-way communication. It allows everyone to volunteer as a news spreader to update and share information about disaster to the public.

These qualifications and potentials are the factors that drive many countries to develop telecommunication specifically for the public relations in the event of disasters.

Concept about sign and color

Using signs and colors for warning and informing people about safety is the basic safety system that results in the visual communication messages.

Using colors and signs can help warn people of dangerous events. During emergency time, this is the easiest way to communicate.

Stock Signs (2010) stated that the Health and Safety (Safety Signs and Signals) Regulations 1996

http://www.gizmodo.com.au

originated from the invention of safety signs to use with staff in case of high risk and inevitable threats. These signs help reduce the risk to human lives and assets at any area and in any work that an employee may be involved such as transporting goods, production, or using heavy machinery. The regulations also set forth traffic signs. Employers have to make sure that they provide adequate information to employees even though some signs may need one-to-one explanation as some are new workers and might not be familiar with the signs.

Safety signs are the information or commands about life and safety on the signs that show signal, color, light, or alarm. It can be verbal or sign language.

Warning signs combine shape, color, and signals or images that are visible alongside messages. These warning signals are categorized according to the type of message being conveyed. The signals allow the usage of specific patterns, colors, spatial specifications, and color proportions.

Findings

1. To communicate about disasters using media in the most useful, suitable, and effective way (target audience in Thailand who has been victims to minor disasters with noncritical damage), it is advisable to use the procedure, method, and channel for public relations as follows:

- Channel 3 TV, 93.0 FM radio station, Thairath newspaper, and Facebook via smart phone

- The suitable time for broadcasting is from 06.01 to 09.00 because it is the time that the target audiences feels the most convenient to follow the news. However, during the disaster, most target audiences will keep following the news all day long.

https://en.wikipedia.org

- The news presentation should be about 6-10 minutes long.

- In a day, the information should be communicated 4 times or once every 6 hours.

- The language should be semi-formal so that people from all groups can understand the message clearly. In the event of disaster, people are going to be scared. So the warning and communication message needs to be immediate, clear, and easy to understand.

- For social media communication, the channel should be controlled by the government or a reliable private organization so that the information is accurate and consistent.

2. Most of the target audience thinks that the warning signs should be in the shape of a red triangles and that the signs showing the evacuation direction should be in the shape of a yellow (or green) circle. The signs should have both a message and an image on them.

Most Thai people think that the disaster warning signs should be triangular while foreigners go for circle. For colors, both groups agree that red is suitable.

For evacuation signs, both Thais and foreigners think that they should be circle. Regarding color, Thais prefer yellow (or green) while foreigners prefer green.

3. Most people in the same group usually contact the government or private agents during the disaster via mobile phone or social media. Therefore, it is important to tell them the telephone number or communication channel as a measure to tackle the problem that might happen anytime.

When in need of help from state agents, the sample group would prefer contacting the agencies via phone. The phone number that comes to their mind is 191. In such event, things that they need the most are food and electricity. In addition, toilet is also important in disaster events.

4. Government and private sectors should prepare tools and equipment used for warning, detect, or transmit the warning signals for an immediate help. For example, they should install

tsunami or earthquake sensing equipment as well as the warning equipment at the broadcasting tower

5. The researcher's assumption was confirmed. People living at different locations are similar in term of how they receive news during disaster, except social media about which each locality has different levels of exposure. This may be because social media is a two-way communication that local people can participate more than in other forms of media. This makes social media vary more in term of usage by location than other traditional media. Therefore, social media should be able to provide accurate information because people in the local area or people in the real disaster area can share their insights. However, users should be aware and verify the accuracy of information shared in social media.

Postscript

1. This research can be further studied for designing new communication media such as disaster warning application that can send messages to private mobile phones so that their owners are immediately aware of the risky incidents. In such application, local people who are trustworthy volunteers can do the two-way communication to assist the victims so that they do not panic, but follow reliable instructions instead.

2. In this research, only 100 foreigners were surveyed. In the next research, it is better to use a bigger sample size, e.g. include Chinese tourists, in order to gain attitude and more opinions of people who travel to Thailand.

3. If there is a disaster event in the future, it is advisable to collect data by using public relations media in the same way as this research suggested. This would help confirm the accuracy and completeness of opinions of the sample groups.

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Management Guidelines for dredged sediment from Lumsai Canal and rice straw in Koiruttagwa Community, Nong Chok

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Introduction

Khlong Lumsai Community or Koiruttagwa is located at Moo 5, Koke Fad District, Nong Chok Area, Bangkok, Thailand. The Koiruttagwa community, comprising 140 households, has been an ancient Muslim community over 130 years (Thai Wisdom Scholars Association, B.E. 2555). The majority of the community depend on agriculture i.e., rice farming and livestock, living peacefully under the Islam doctrine and the philosophy of the sufficiency economy. Lumsai canal, connected to Sansab canal, is the main source of water for farming and livestock.

Through an interview with the community leader, Ajarn Somchai Samarntrakul, it was found that the community suffers from a problem with management of dredged sediment accumulation in the waterway, as well as the problem of waste from burning of rice straw, which causes environmental harm and damage to the scenery. The community has managed the dredging of canal sediment due to flooding in the area in 2011, in order to improve the canal's draining efficiency. However, there is no management plan for disposal of the dredged sediment. Most people took the dredged sediment and fill along the canal which is useless (Somchai Samarntrakul, interviewed, 2013). Surveying the problem in Lumsai Community in Nong Chok District, Bangkok, it can be stated that there are the useless dredged sediment accumulation and the burning of the agricultural waste and rice straw causes severe environmental pollution.

In this study, dredged sediment and rice straw from Lumsai Community were used in the production of bricks, briquettes for fuel and organic fertilizer. Life Cycle Assessment (LCA) was used to evaluate the environmental impact in order to establish management guidelines to address the environmental problem- in this case, to reuse the dredged sediment and rice straw.

Life Cycle Assessment (LCA)

Life Cycle Assessment (LCA) is an evaluation process to establish the environmental burden of producing products, production processes or activities by determining and classifying the amounts of energy and materials used as well as the waste released. The objectives are to assess the environmental impact from energy and material usage, and to determine the quantity and opportunity for improvement. The evaluation covers the product life cycle, and processes or activities as follows: resource extraction and refining, transportation and distribution, use and re-use, maintenance, recycle and waste management. (Society of Environmental Toxicology and Chemistry, 1990).

According to ISO 14040:2006, the four steps of LCA are (1) goal and scope; (2) life cycle inventory; (3) life cycle impact assessment; and (4) interpretation.

Management of dredged canal sediment by production of bricks, fuel briquettes and organic fertilizer

In this study, dredged sediment and rice straw were used to produce bricks, fuel briquettes and organic fertilizer using life

cycle assessment (LCA) as a tool for environmental impact evaluation (Figure 1).

1) Production of bricks from dredged canal sediment using rice husk and straw

In this study, brick production uses dredged sediment from Lumsai Canal, together with crop waste (rice husk and straw) as raw material. Dredged sediment was physically and chemically studied then mixed with rice husk in five proportions based upon their percentage weight (dredged sediment: rice husk): 100:0, 95:5, 90:10, 85:15 and 80:20. Properties of the bricks produced were compared in order to get the correct ratio. The same procedure was applied to the production of bricks from dredged sediment using rice straw. The brick must be compliant with the Industrial Standard 77-2545 for building bricks.

It was found that Lumsai Canal dredged sediment has the properties of clay, with the chemical composition: SiO_2 56.27%, Al_2O_3 11.76% and Fe_2O_3 7.84%. Percentage of the heavy metal is as allowed by Announcement No. 25, B.E. 2547 of the National Environmental Board for soil quality standards under the Pollution Control Department. The study showed the optimal ratio for brick production, in terms of percent weight of dredged sediment: rice husk, is 95:5. Standard testing for other properties of brick revealed low water adsorption (18.48%) high compressive strength (8.02 MPa) with the dimension and error within the range of standard criteria. It was not possible to produce brick from dredged sediment and rice straw proportion at 90:10, 85:15 and 80:20.

2) Production of fuel briquettes from dredged sediment with rice straw

The optimal proportion of dredged sediment and rice straw was studied using cassava as binder. First step, the quantity of binder was determined by mixing the raw material, dredged sediment and rice straw, with the binder in four different proportions; 20%, 25%, 30% and 35%. The results indicated the optimal percentage by weight of binder was 20%.

In order to determine the ideal proportions of dredged sediment and rice straw, 20% of binders were mixed in the five proportions, i.e., 100:0, 75:25, 50:50, 25:75 and 0:100. The mixtures were processed to yield five different fuel briquettes. The Thai Industrial Standard Institute (B.E. 2547) which specifies

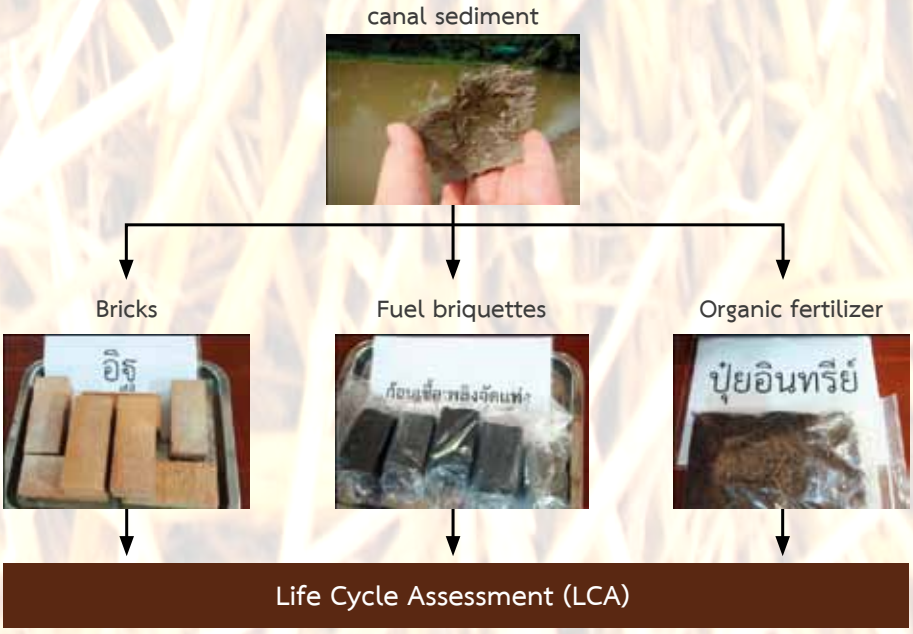

Figure 1 Life Cycle Assessment, LCA
Source: Supakata (2015)

standards for community products, requires that fuel briquettes should possess the following properties: at least 75% of fixed carbon; less than 25% of volatile matter; 8% ash; 10% moisture and at least 5,500 calories/gram of heating value. A compression test of fuel briquettes is also required.

The results showed the optimal proportion of sediment: rice straw was 25:75. The measured properties of the briquettes produced were as follows: moisture (0.81%), volatile matter (0.19%), ash (13.67%) and fixed carbon (85.17%). The calorific value as measured using a bomb calorimeter was 1,555.8 calories/gram. Compressive strength value measured using a compression machine was 616.7 Newtons. In conclusion, the properties of the produced fuel briquettes were within the requirements of the national standard for fixed carbon, volatile matter and moisture content. However, the ash content and heating value require further study.

3) Production of organic fertilizer from dredged sediment with rice straw

This study aimed to establish the optimal proportion of dredged sediment from Lumsai canal and rice straw, in the production of organic fertilizer. The carbon: nitrogen ratio (C/N ratio) of the raw materials was 14.85 for dredged sediment and 11.63 for rice straw. The optimal ratio of dredged sediment to rice straw was determined by setting their weight into four ratios: 12:0, 8:4, 6:6 and 0:8 kg. For the fermentation process, 6.5 kg of cow manure and 0.25 kg of urea fertilizer were added to each mixture. During the 45-day fermentation process, temperature and moisture of the fertilizer produced were measured. Following fermentation, the chemical properties of the organic fertilizer were analyzed and compared with starting and standard values of Thailand's Department of Agriculture.

The results revealed C/N ratios of 7.02, 7.36, 6.03 and 8.11 for the four mixtures, respectively. This signifies a reduction in C/N ratio relative to the raw material (dredged sediment and rice straw) in all four mixtures. The optimal ratio of raw materials (dredged sediment: rice straw) for organic fertilizer was 6:6. The measured properties consisted of moisture content and volatile matter (61.57 ± 0.32) had values greater than the standard not more than 30%, organic material (21.27 ± 0.25), acidity and basicity (6.83 ± 0.04), electrical conductivity (5.59 ± 0.03 decimen/meter), primary nutrients (total N 2.05 ± 0.14%, total P_2O_5 2.51 ± 0.11%, total K_2O 2.78 ± 0.36%). Heavy metals including arsenic, cadmium, chromium, copper, and lead agree well with the respective standard values of the Department of Agriculture for organic fertilizer (B.E. 2548).

Life Cycle Assessment of produced brick, fuel briquettes and organic fertilizer

A commercial program based on CML 2 baseline 2000 method version 2.03, SimaPro 7.1, was applied to evaluate the LCA of the brick, fuel briquettes and organic fertilizer. Production of bricks and organic fertilizer were found to result in significant environmental impacts: global warming, human toxicity, acidification and eutrophication, in order of importance. In contrast, the fuel briquettes had more impact on human toxicity than on global warming. The most significant driver of environmental impact was the electrical energy used in production processes, especially for the drying process for fuel briquettes, the burning process in brick production, and diesel fuel used in transportation of raw materials. Comparing all environmental impacts of those three products based on the ratios of raw materials, production of fuel briquettes created the largest environmental footprint of all three options studied.

Additionally, considering the production cost of these three products (brick, fuel briquettes and organic fertilizer), it was found that the optimal way to manage the dredged sediment from Lumsai canal as well as rice straw residues was to use both materials to produce organic fertilizer. Production of organic fertilizer

Figure 2 Talk entitled "Participation of people in the community for Lumsai Canal dredged sediment management.
Photographed by: Supakata et al., 2015

entailed lower investment in equipment and technology compare to brick and fuel briquettes, which require higher investment in machinery such as kilns, dryers and moulds.

Researchers discussed the outcomes with the community at the Sufficiency Economy Learning Center, Koiruttagwa Community, Nong Chok, Bangkok (Figure 2)

The discussion presented the study results, indicating that production of organic fertilizer was the most suitable product that would fills the need of the community. The community suggested various forms of the fertilizer such as briquettes or pellets in order to make it easy to store and use. Although the community was also interested in brick production, the need to invest in equipment was an obstacle to this opportunity.

Conclusion

Our study of dredged sediment management at the Koiruttagwa Community, Nong Chok District, Bangkok showed that the properties of dredged sediment in Lumsai Canal are suitable for making bricks, fuel briquettes or organic fertilizer. Comparing the cost, production technology and environmental impact, organic fertilizer production was found to be the most appropriate way to manage the dredged sediments and rice straw residues. In discussion with the community members, the organic fertilizer production was accepted by community members as the optimal solution for managing these two waste products.

Acknowledgements

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ARTICLE

Novel Non-Tracking Solar Panels for Process heating Applications

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Introduction

Solar energy in Thailand has a high potential both for electricity production using photovoltaic (PV) cells, and also for direct conversion into heat energy. Traditional household water heaters are typically equipped with vacuum tube solar panels or flat plate solar panels that can heat only to 60-70°C. In order to achieve temperatures above 100°C, the solar panels must be equipped with concentrating solar collectors such as parabolic troughs or parabolic dishes that track the sun's daily trajectory. In practice, such tracking systems are not suitable for small solar arrays due to technical complexity, higher prices and higher risks of failure. Moreover the high level of diffuse solar radiation in Thailand presents a further constraint. The diffuse solar radiation rate in Thailand ranges from 31% to 58% (Chanchai and Laksanabunsong, 1999), reducing the effectiveness of concentrating solar collectors in making use of diffuse radiation.

Figure 1 System of 30 solar panels for office air conditioning at the Energy Research Institute, Chulalongkorn University
Photographed by: Ratismith, December 2015

These limitations leave the researchers with the question: how to make the solar collector receive sunlight all day long without the help of a solar tracking system, to allow it to be used effectively in Thailand despite high levels of diffuse solar radiation, and secondly to raise maximum temperatures achievable compared with solar panels currently available in the market.

The solar panel developed as a result of this study has unique properties, and was patented in Thailand on December 23, 2014 (Patent number 42401) (Ratismith, 2014). This solar panel consists of 2 innovations, the first comprising a non-tracking solar collector. A compound parabolic concentrator (CPC) is designed to collect sunlight throughout the day without solar tracking system. The CPC is also able to collect diffuse solar radiation effectively, making it ideal for using in Thailand.

The second innovation is the use of a manifold heat pipe that can transfer heat from the head of the heat pipe (alternatively referred to as the header) directly to the working fluid, helping to increase efficiency of heat transfer.

Together, both innovations enable the developed solar panels to achieve higher temperatures than commercialized solar panels currently in the market (Ratismith Inthongkhum and Briggs, 2014). The new development thus extends the scope application from households, apartments, condominiums, resorts, and hospitals to industrial use, e.g. for heating in factories using hot water, oil or air. The newly developed solar panel can now compete with other solar panel designs available in the market and reduce the country's dependence on technology imports. Moreover, the breakthrough will increase utilization of the potential of Thailand's solar energy resources, reduce fossil fuel consumption, and protect the environment.

Mathematical Model of Ray-Tracing

The design of the CPC solar panel consists of 2 parabolic graphs with suitable conditions with a number of parameters such as the constant of parabolic equation, height, width of the graph, and rotating angle. The 2 parabolic graphs would rotate inward each other until the base of the panel is flat and perfectly connected with each other. The upper portion of the CPC panel intersects the point where the graph line is vertical in order to have the biggest width. The shape of the reflection would look like a teacup. The design allows this solar panel to have an acceptance angle as large as 127 degrees (Figure 2) (Winston and Hinterberger, 1975; Canaff and Ratismith, 2015; Ratismith and Favre, 2015) and also to collect sunlight from different directions (Figure 3).

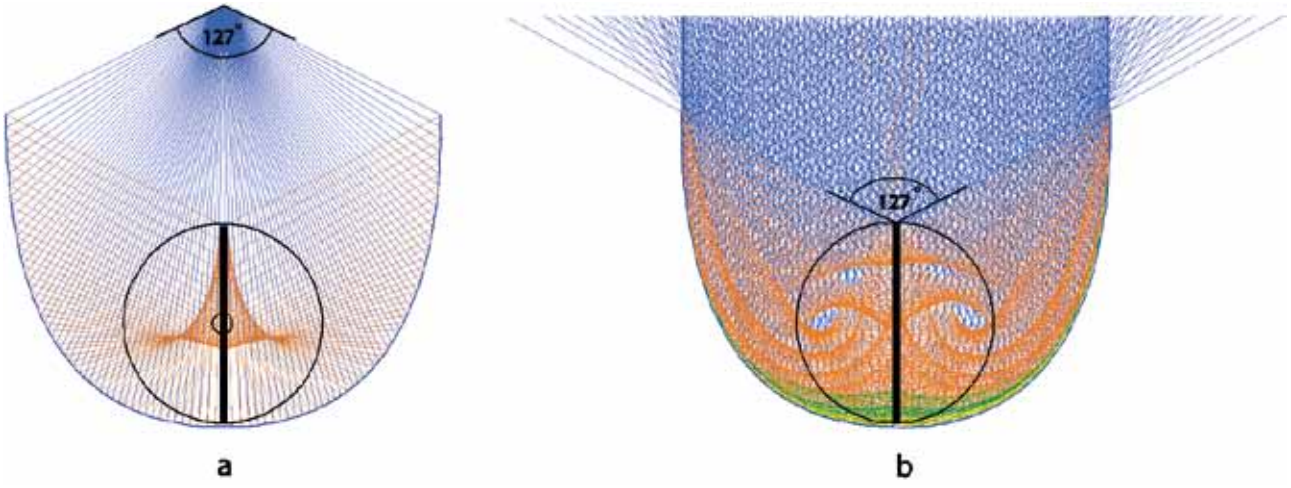

Figure 2 Model of diffuse radiation reflection, the circle represents vacuum tube, the straight line inside the vacuum tube represents a vertical absorber with the acceptance angle up to 127 degrees
Source: Ratismith, Inthongkhum, and Briggs (2014)

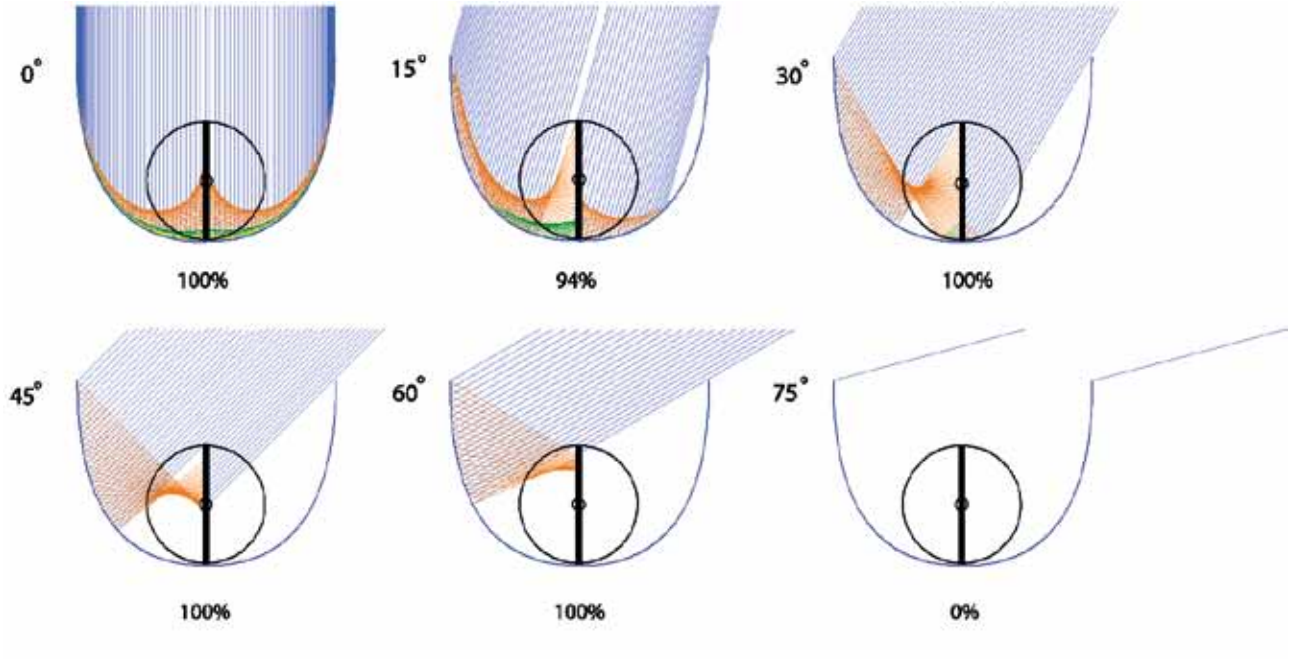

Figure 3 Model of ray-tracing of solar panel from different angles (0-75 degrees); at 0-60 degrees, the solar panel can collect almost 100% reflected rays without solar tracking system. However at 75 degrees, the solar panel cannot concentrate the radiation on the vacuum tube.
Source: Ratismith, designed in December 2015

Improvement of Manifold Heat Pipe with Metal-to-Water Contact

The authors developed an innovative design for the manifold heat pipe in order to transfer heat directly to the heat media. At present, there is no such heat transfer method in any commercial solar panel. Instead, products currently available on the market exchange heat by transferring heat outside the metal pipe, resulting in high loss of heat at the joint of the materials. The newly developed heat transfer pipe is also designed to prevent water leaks and resist high pressure condition. It can also be easily removed for cleaning, in order to maintain high solar collecting efficiency throughout its lifetime (Figure 4).

Figure 4 Installation of Direct Heat Transfer to Water system, resulting in more efficient heat transfer than other solar panels in the market and can operate under high pressure condition.
Photographed by: Ratismith, December 2015

Solar panel efficiency test

The developed solar panels were tested according to ISO 9806 (Figure 5). Water flowing through the solar panels transferred heat to the water and raising the temperature of the outgoing water. The water then flowed from the solar panels to the cooling tower. The electric heaters are used to control to have the constant inlet temperature. The system recorded temperature values at 1-minute intervals. When the data of incoming water temperature was derived, the next step was to heat the incoming water to 40-90°C. The resulting data were analyzed to calculate the efficiency of the solar panels and define an efficiency curve according to ISO 9806 (Kearney, 1989; Brunold, Frey, and Frei, 1994; Fraunhofer Institute for Solar Energy Systems ISE, 2007; Helal et al., 2011; Nkwetta and Smyth, 2012).

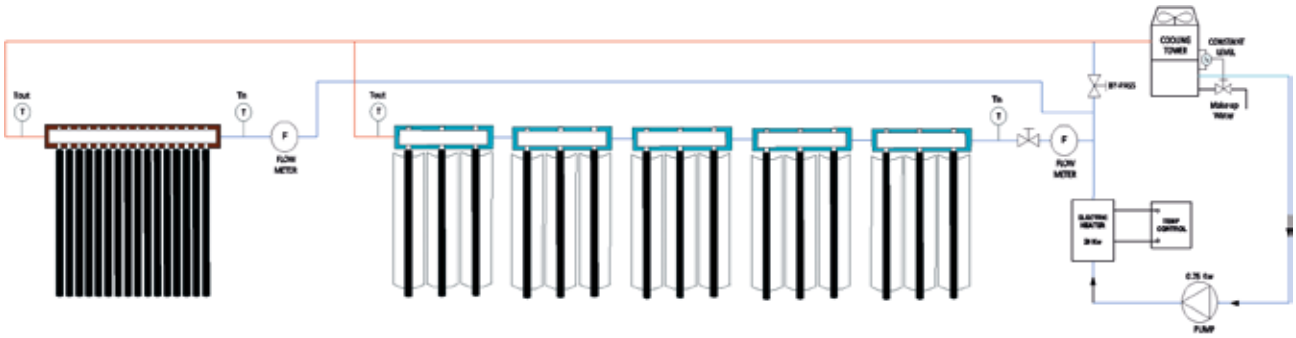

Figure 5 Diagram of solar panel efficiency tested for the 5 developed solar panels and 16 evacuated tubes solar panel connected with the water pumping system, cooling tower, heaters and control system
Source: Canaff and Ratismith (2015)

Heat power (W) received from the solar panel comes from the following equation:

$$Q_C = \dot{m}C(T_e - T_i) \quad (1)$$

Where Q_c = heat power (W) in the function of time
$\dot{m}$ = flow rate (kg/s)
C = specific heat (kJ/kgK)
t = time
T_e(s) = exit temperature (°C)
T_i = inlet temperature (°C)

Efficiency of solar panel (η) is calculated from the following equation:

$$\eta = \frac{Q_C}{A\,G} \quad (2)$$

Where A = gross area of solar collector
G = solar power *(W/m²)*

Efficiency of solar panel according to the standard of ISO 9806 comes from the following equation

$$\eta = \eta_0 - c_1 x - c_2 G x^2 \quad (3)$$

Where

$$x = \frac{T_m - T_a}{G} \quad (4)$$

Where $T_m = (T_e + T_i)/2$ = average temperature
T_a = ambient temperature
c_1 and c_2 = constant value

By testing the efficiency of solar panels at any time of the day, it was found that the newly developed solar panels were more efficient in collecting solar energy throughout the day, delivering steady efficiency from 10.00 to 16.00 without the requirement for a solar tracking system (Figure 6).

The solar energy delivered by the solar panels can be calculated from Equation (1). Based on the test, it was found that the output power received from the 5 newly developed solar panels using 15 evacuated tubes was double that obtained from conventional evacuated tube solar panels using 16 evacuated tubes (Figure 7). In addition, with the same area of solar panels between newly developed solar panels and evacuated tube solar panels, it was found that the newly developed solar panel could reduce the need for vacuum tubes by about 50%, resulting in a lower-cost system.

Considering heat transfer of the solar panels, it was found that the temperature differences in the newly developed solar panels were consistent with variations in solar irradiation. In contrast, temperature differences for the vacuum tube solar panels bore a weaker relationship with solar irradiation. This highlights the ability of the newly developed solar panels to transfer heat to water and react quickly to variation in solar irradiation, as compared to the vacuum tube solar panels (Figure 9).

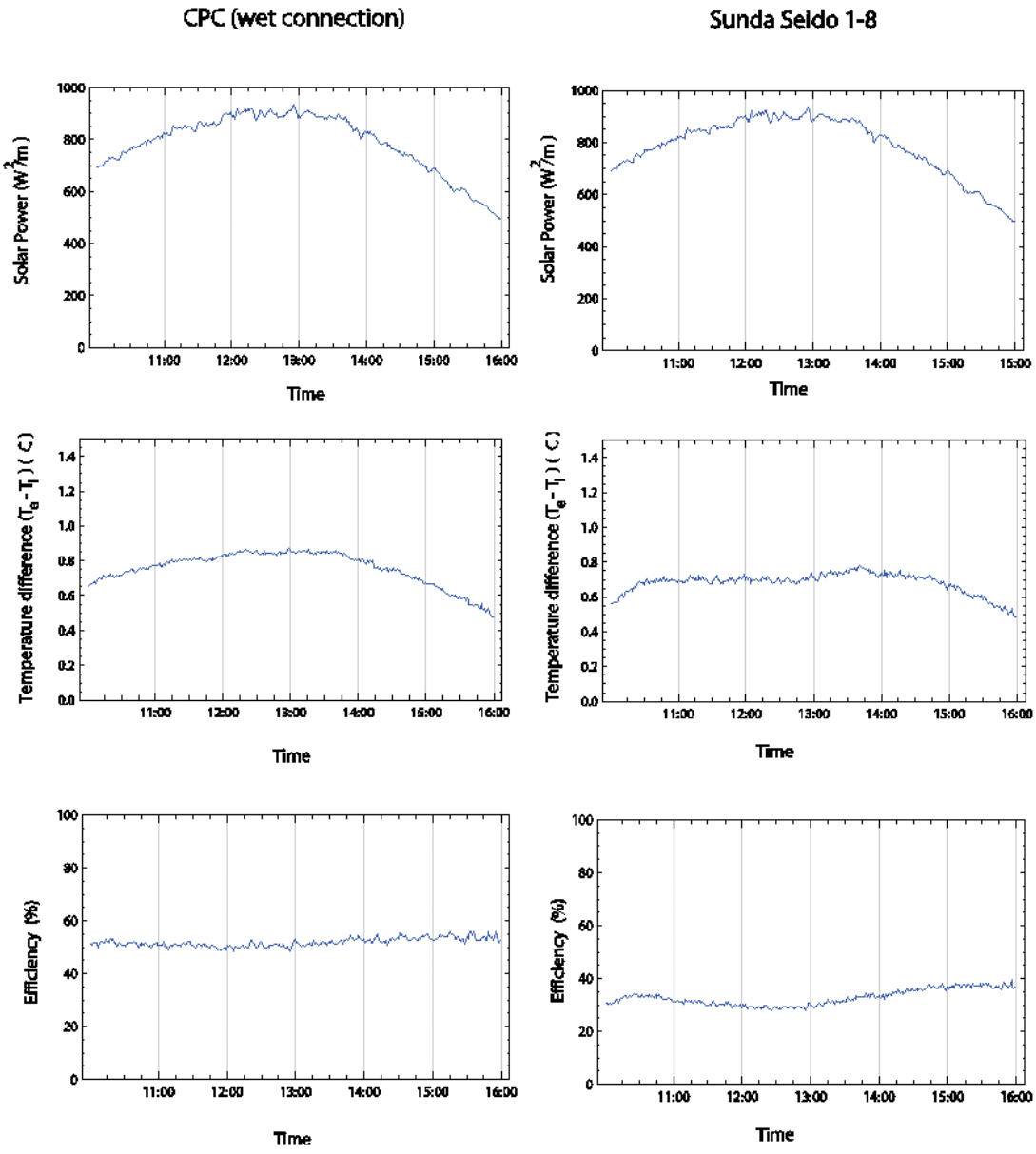

Figure 6 Comparison of solar power, temperature difference, and efficiency at any time of the day from 10.00 a.m. to 4.00 p.m. of the CPC solar panel (left) and evacuated tube solar panel (right)
Source: Ratismith and Favre (2015)

Figure 7 Evacuated tube solar panels (left) and 5 of the newly developed solar panels (right)
Photographed by: Ratismith, December 2015

The efficiency test of 5 CPC solar panels (15 tubes) and evacuated tube solar panel (16 tubes), indicated that the CPC design was more efficient than the commercial evacuated tube solar panel (Figure 10). The efficiency equation for the CPC solar panels is η = 54.45-241.73 $x \pm$ 2.5 with a standard deviation of 2.66. The efficiency equation for the evacuated tube solar panel is η = 48.66-283.78 $x \pm$ 2.5 with a standard deviation of 3.03 when tested on a clear sky day. The direct heat transfer system improved heat transfer efficiency compared with conventional commercial systems, and also enabled the newly developed solar panels to function under high pressure.

Conclusions

The CPC solar panel was found to be more efficient than commercial evacuated tube solar panels in collecting sunlight throughout the day without the assistance of a solar tracking system, and also collects diffuse solar radiation more efficiently. It is therefore suitable for all weathers, especially in Thailand where diffuse radiation is at a high level. The high-efficiency heat transfer tube in the new design transfers heat directly to the working fluid- a much more efficient process than is currently achieved with commercially-available systems, and with the added advantage that the system can function under high pressure condition without risk of leakage. The current study found that the newly-developed solar panel is about 10% more efficient than the evacuated tube solar panels currently available in the market. This could reduce the need for number of evacuated tubes by 50%, lowering total system costs. Moreover, the CPC solar panel can generate more heat than flat solar panels or vacuum tube solar panels and thus has more diverse uses apart from heating water. This solar panel design can be used for industrial heating processes as well as in hotels, resorts, and hospitals. The development of the PCP solar panel prototype

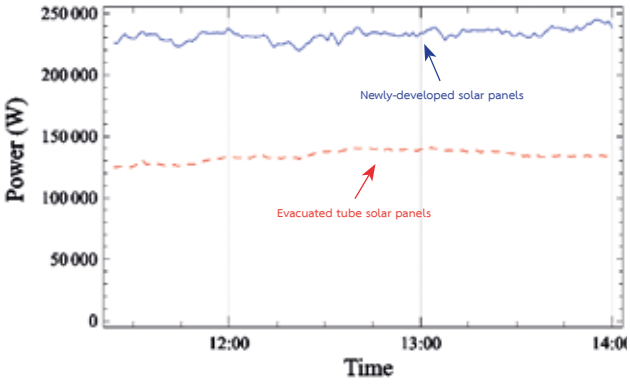

Figure 8 Comparison of out put power delivered by both types of solar panel: newly-developed solar panels (15 tubes) produce double the out out power of commercial evacuated tube solar panels (16 tubes) with similar number of tubes
Source: Canaff and Ratismith (2015)

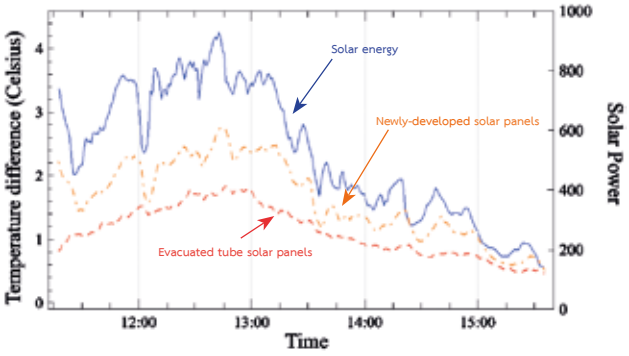

Figure 9 Temperature differences for both types of solar panels and solar power (W). The blue, orange dot-dash and red dash lines represent solar power, temperature differences of developed solar panels and vacuum tube solar panels respectively
Source: Canaff and Ratismith (2015)

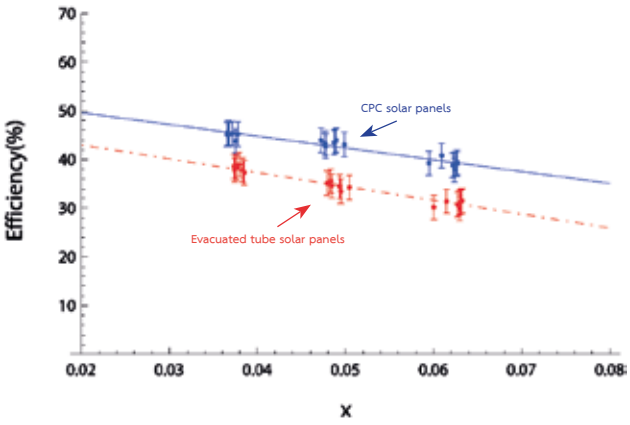

Figure 10 Efficiency curves of 5 CPC solar panels (15 tubes) and 1 evacuated tube solar panel (16 tubes) tested on a day with clear sky.
Source: Ratismith, processed in December 2015

thus represents a major technological breakthrough, which is expected to be commercially applied in the near future.

Acknowledgements

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Yield and Postharvest Quality Improvement of 'Butterhead' Lettuce Using Chitosan Waste

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Introduction

Lettuce *(Lactuca sativa* L.*)* is a popular salad vegetable; however, there is an increasing consumer awareness of chemical contamination stemming from chemical fertilizers and pesticides applied in crops. Consequently this has led to an increased preference for crops organically produced along side those produced with minimal amounts of synthetic chemicals.

Chitin and chitosan are biopolymers that are used increasingly as a replacement for synthetic chemicals. Found in crustaceans such as shrimps, crabs, and insects, chitin is a linear polysaccharide consisting of N-acetyl-2-amino-2-deoxy-D-glucose connected with beta 1,4-glycosidic bonds. Chitosan is a biopolymer resulting from the deacetylation of chitin molecules. Thailand has an enormous chitin and chitosan production potential due to the large volume of low-cost raw materials produced as waste from its aquaculture and prawn processing industries.

Including the use of chitosan to enhance germination (Wongchai et al., 2004) or to accelerate growth and increase yield, there have been many previous studies on the diverse applications of chitin and chitosan in agriculture. It should be noted that responses to chitosan may differ depending on specie of crops, types of chitosan, method of application, and system of farming. Limpanavetch et al. (2008) found that foliar application of 80% deacetylation chitosan could stimulate flowering in *Dendrobium* orchids. The study revealed that chitosan increased the number of blossoms per bunch and that all types and rates of chitosan application resulted in faster flowering compared with untreated controls.

Apart from application helping preserve cut-flower plants, chitosan is also an efficient growth enhancer for vegetables such as Chinese kale and chili peppers. It was found that weekly applications of chitosan on Chinese kale for a period of 2 months boosted crop yields. Using the same application rates as for the Chinese kale, it was found that chitosan-sprayed chili peppers grew higher than unsprayed controls (Chandrkrachang, Sompongchaiyakul and Tuantai, 2003).

Leftover from the chitosan synthesis process is residual waste material, which comprises mostly of organic substances and microbes, used during the process. Interestingly, the leftover waste from these tanks can be further processed into semi-biological crop fertilizers.

The purpose of this research project is to develop an approach to produce lettuce with minimal use of synthetic chemicals by applying wastes or residues from the chitosan processing tank to increase yield and improve produce quality of the harvested lettuce.

Growing Butterhead Lettuce Using Chitosan Wastes

The 'Butterhead' lettuce was used for this study. 'Butterhead' lettuce seeds were germinated and transplanted at day 7 to a tray containing a mixture of fine soil, manure, and rice hulls at the ratio of 1:1:3, respectively. The tray was placed in a greenhouse under shade for 3 days, and then in sunlight for 7 days. Manure was added every 3 days. When the seedlings were 14 days old, they were moved from the growhouse to the test plot to get the plants to adapt to the growing environment. The seedlings were grown in the test plot until 21 days old.

Holes about 15 cm deep and 30 cm apart were prepared in the test plot, and a growing medium of manure and soil were mixed together. Each plot had 3 rows of 30 planting holes. The controlled test plot was filled with 100g of manure per hole and mixed with soil. After hay mulch was used to cover the ground, the test plots were then watered. The lettuce seedlings were transplanted from the nursery tray to the test plots (1 plant per 1 hole). The plants were watered twice a day, mornings and evenings. After 1 week, 100g of manure per plant was added to the control plot, while the chitosan test plot received 20g of chitosan waste. Two weeks later, 50g of manure was added to each plant in both the control plot and the chitosan waste test plot. When the lettuce plants were 8 weeks old, growth and yield data were recorded. Both plots were then harvested and stored in plastic bags at 8°C for 14 days. Quality of lettuce after harvesting was analyzed. The same test was carried out in 2 crop seasons: one from January - March and the other May - July.

Effect of chitosan waste on crop yield and quality

The results of the study conducted over two crop seasons indicated that chitosan boosted the growth of 'butterhead' lettuce when compared with the control plot. Lettuce plants grown using chitosan waste had an average of 19.57 leaves per plant and head diameter of 24.62 cm, while those grown in the controlled test plot had an average of 17.02 leaves per plant and head diameter of 19.34 cm. In the analysis of total nitrogen, available phosphorus, potassium, calcium, and magnesium in cow manure

Figure 1 Chitosan wastes and the growing material used in the test
Source: Seraypheap et al. (2015)

and in chitosan waste, it was found that chitosan waste had higher levels of total nitrogen, exchangeable phosphorus and potassium than cow manure, but alternatively, cow manure had higher exchangeable calcium and magnesium than chitosan waste. Soil mineral analysis revealed no significant differences in total soil nitrogen between the chitosan waste and control plots. Analysis of soil minerals pre-season and after harvest revealed that the chitosan plot had higher total nitrogen and exchangeable phosphorus, potassium, calcium, and magnesium than the control. This higher level of minerals availability was a key factor in explaining the higher growth in chitosan plots compared to the control.

In addition, lettuce plants from the chitosan waste test plot had significantly higher fresh and dry weight compared with the control. Chitosan-grown lettuce had an average fresh weight of 53.11g per plant in the first crop season and 40.09g in the second. On the other hand, lettuce grown in the control plot had an average fresh weight of 22.41 in the first crop season and 30.28g in the second. When stored in a temperature-controlled cabinet at 8°C for 14 days, it was found that the lettuce plants from the chitosan waste test plot lost significantly less water than those from the controlled test plot. The water loss rate of the former was 8.30% while that of the latter 11.86%.

This study over two crop seasons revealed that chitosan waste considerably enhanced growth of lettuce, especially in terms of fresh and dry weight, without using chemical fertilizers.

Figure 2 Growth comparison of butterhead lettuce at 8 weeks old
Source: Seraypheap et al. (2015)

The study shows the value of chitosan waste as an alternative to chemical fertilizers. Moreover, chitosan waste is also known to increase total soil organic matter, thus contributing to longer-term improvement to soil structure and abundance of soil microflora (Seraypheap, Chadchawan and Wangsomboondee, 2015) and sustainable farming in subsequent seasons. Soil incorporation of chitosan can stimulate growth of lettuce and increase yield and also has the ability to capture ions of essential plant mineral nutrients including phosphate, potassium, calcium, magnesium, and iron. These minerals are made available gradually to plants so that less is lost to groundwater through leaching. Finally, chitosan as an ionic biopolymer can increase the effectiveness of the exploitation of soil minerals, resulting in higher yields, confirming the results of previous studies.

The enhanced growth of lettuce in this test could be explained either as a consequence of higher availability of essential plant nutrients or by the effect of hormone-like substances resulting from decomposition of chitin-chitosan in the soil by the action of beneficial soil micro-organisms. Soil incorporation of chitosan before and after transplanting could improve soil quality (increased nutrient availability) and also enhance the soil's water-retention capacity. Chitosan waste has also been reported to stimulate the immune system of some plant species (Amborabé et al., 2008). With sufficient nutrients for growth and higher photosynthesis capability, the lettuce plants in the chitosan waste test plot produced more leaves per plant, larger leaves, larger head size, and higher fresh and dry weight of harvested lettuce. All these improvements lead to a higher quality harvest with a longer shelf life.

Conclusions

In both crop seasons, mixing 20 grams of chitosan waste with the growing medium before growing and after growing for 1 week enhanced growth and yield of butterhead lettuce compared to the control plot. Moreover, application of chitosan waste also improved yield quality and shelf life. Therefore, chitosan waste is an attractive option that farmers can choose in order to increase yield and quality, while reducing the use of synthetic fertilizers and improving soil quality in the longer

Acknowledgements

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Attachment and entrapment immobilization of cyanobacteria *Synechocystis* sp. cells using chitosan

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Introduction

The removal of phosphorus accumulated in the recirculating aquaculture system (RAS) is a bottle neck of long term water reuse. In general, phosphorus derived from feeding is accumulated in the RAS throughout the culture period. This is unlike nitrogen removal process in which nitrogen can be removed as nitrogen gas after the denitrification treatment. Previous research illustrated that the cyanobacteria *Synechocystis* sp. PCC 6803 could remove phosphate from the RAS water by phosphate assimilation. (Burut-Archanai et al., 2013) However, the removal of phosphate accumulated *Synechocystis* sp. cells required complicated process such as centrifugation. Therefore, it cannot be further applied with large scale RAS.

To achieve the phosphorus removal process using cyanobacteria, it is necessary to retain *Synechocystis* cells in the culture reactor. This could be performed by cell immobilization technique. In general, there are two common procedures available for cell immobilization which are attachment and entrapment in polymers. For attachment, cells are bound to the surface of the solid particles. In case of entrapment, the cells are entrapped within porous structures either preformed or formed in situ around the cells. With this study, chitosan was chosen as the immobilization matrix as it has several perceived advantages. Chitosan or poly [ß-(1⟶4)-2-amono-2-deoxy-D-glucopyranose] is a biopolymer mainly extracted from shrimp biowaste. It is non-toxic, biodegradable and biocompatible with cationic character. Chitosan is stable in phosphate solution and the immobilization process can be performed at room temperature with various salinity (Vorlop and Klein, 1987). Therefore, this study was investigated the efficiency of chitosan flakes and beads for immobilization of *Synechocystis* cells. The

immobilized *Synechocystis* would be further used for phosphate removal in the recirculating aquaculture systems.

Study of the attachment and entrapment immobilization of cyanobacteria *Synechocystis* sp. cells using chitosan

In the study of the attachment and entrapment immobilization of cyanobacteria *Synechocystis* sp. cells using chitosan, the Stock of cyanobacterium, *Synechocystis* sp. PCC 6803 was grown in BG-11 medium with the same condition as described by Burut-Archanai et al. (2013). Chitosan with the molecular weight of 270 kilodalton and degree of deacetylation of 90% was purchased from A.N. Laboratory (Samut Sakorn, Thailand). In this study, chitosan was prepared in various forms as described as follows:

1. Preparation of chitosan flakes for cyanobacteria immobilization

Chitosan was ground and sieved to get the size of 1 millimetre (small size; S), 2 millimetre (medium size; M) and 3.35 millimetre (large size; L) in diameter. The surface of chitosan flakes were modified by soaking in 100 millimolar of acetate buffer at pH 5.5, phosphate buffer at pH 6.5, or pH 7.5 for 2 min before mixing with the *Synechocystis* cell suspension at the chlorophyll-*a* concentration of 1 microgram/millilitre. The ratio of chitosan/cell suspension was 0.5 gram: 20 millilitre. After mixing, the chitosan immobilized *Synechocystis* was continuously shaken at 120 revolution per minute. Within the 48 hours-experiment, chitosan flakes were sampled filtered and washed twice with deionized water before extracting the attached chlorophyll-*a*. The immobilization efficiency of chitosan was presented as the amount of cyanobacterial chlorophyll-*a* attaching on chitosan flakes.

2. Preparation of chitosan beads for cyanobacteria immobilization

Chitosan solution was prepared at 3% (weight/volume) in 0.5% (volume/volume) acetic acid solution and pH was adjusted to 6 before mixing with the cyanobacterial cell suspension. The cell suspension was concentrated by centrifugation and adjusted the optical density at 730 nanometre (OD_{730}) to 1.2. Concentrated *Synechocystis* cells were mixed with chitosan solution with 3 different ratios including 1:1 (low cell/chitosan ratio: L), 2:1 (medium ratio: M), and 3:1 (high cell/chitosan ratio: H). The mixture was then dropped in 1% (weight/volume) NaOH solution and curing for 5 minute followed by soaking in deionized water for 20 minute. The cell-chitosan beads were then filtered and resuspended in 0.1 molar Tris buffer (pH 7.5). The washing process was repeated several times until pH of the buffer became neutral.

3. Growth of immobilized *Synechocystis*

The cell density was measured using a spectrophotometer at 730 nanometre. The cells immobilized on chitosan and the remaining cells suspended in the medium were monitored using chlorophyll-*a* concentration. The chlorophyll-*a* analysis was performed by extracting cells with *N*, *N*-dimethylformamide and measured using a spectrophotometer at 625 and 664 nanometre (Moran, 1982). The chlorophyl analysis was done in triplicate.

Results of immobilization of cyanobacteria on chitosan flakes and cyanobacterial cells in chitosan beads

1. Immobilization of cyanobacteria on chitosan flakes

The immobilization of cyanobacteria on chitosan flakes in terms of chlorophyll-*a* content as a function of immobilization time and particle size of chitosan

flakes (Figure 1). The attachment of cyanobacterial cells on the surface of chitosan increased in proportional to immobilization time upto 24 hours and remained constant afterward (upto 48 hours). On the other hand, the smaller size of chitosan shows the larger amounts of cyanobacteria (chlorophyll-*a* content) attached on the surface of chitosan. For example, the highest chlorophyll-*a* content (17 microgram Chl-*a*/gram chitosan) was found on the surface of chitosan with the smallest size whereas chlorophyll-*a* content about 13 microgram Chl-*a*/gram chitosan and 11 microgram Chl-*a*/gram chitosan were found on the surface of medium-sized and large-sized chitosan, respectively. Similar results also observed by Lertsutthiwong et al. (2013). The smaller size of chitosan flakes has higher surface area, resulting in larger amounts of cells attaching on the surface of chitosan. Therefore, the 24 hours was chosen as the optimal immobilization time and this condition will be used for the further studies.

Effect of pH treatment on cyanobacteria immobilization on chitosan flakes is shown in Figure 2. At initial, the cells attached on chitosan surface treated with buffer at pH 5.5 was below 5 microgram Chl-*a*/gram chitosan whereas those treated with buffer at pH 6.5 and 7.5 were about 7 microgram Chl-*a*/gram chitosan. After 24 hours of immobilization time, the chlorophyll-*a* content on the surface of chitosan treated with buffer at either pH 5.5 or 6.5 did not show significantly different chlorophyll-*a* content among the sizes (1 millimetre - 3.35 millimetre flakes). However, the highest amounts of chlorophyll-*a* content was found on the surface of smallest-sized chitosan in alkaline condition (pH 7.5).

2. Immobilization of cyanobacterial cells in chitosan beads

In this study, *Synechocystis* immobilized in chitosan beads were grown in BG-11 medium and the chlorophyll-*a* concentration either in beads or medium was monitored during 14 day-experiment. The results demonstrated that the cell started to grow in beads after 3 days of immobilization and the

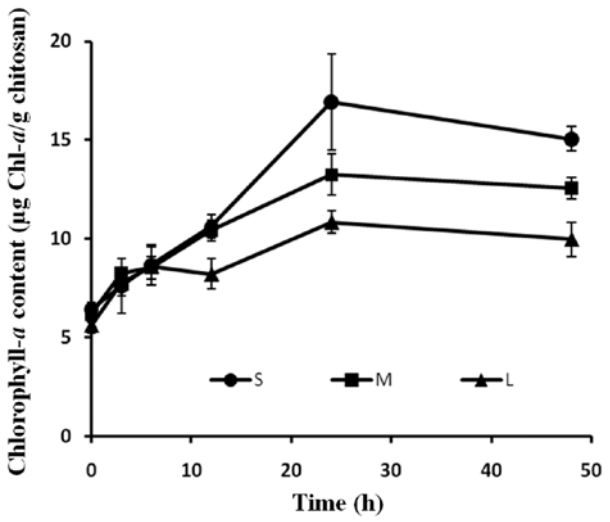

Figure 1 Chlorophyll-*a* content of *Synechocystis* cells immobilized on chitosan flakes with different sizes of 1 millimetre (S), 2 millimetre (M) and 3.35 millimetre (L)
Source: Rojsitthisak et al. (2015)

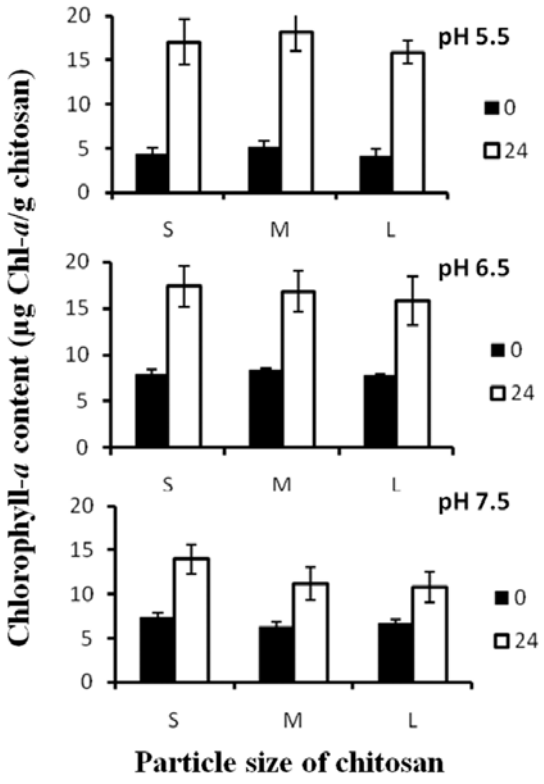

Figure 2 Effect of pH treatment on cyanobacteria immobilization on chitosan flakes with small (1 millimetre: S), medium (2 millimetre: M) and large (3.35 millimetre: L) particle sizes.
Source: Rojsitthisak et al. (2015)

lower cell/chitosan ratio-beads contained the lower concentration of chlorophyll-*a* (Figure 3). For example, at day 14, the chlorophyll-*a* concentration in low cell/chitosan ratio-beads was about 1.2 microgram Chl-*a*/gram chitosan whereas the medium cell/chitosan ratio-beads and high cell/chitosan ratio-beads were about 4.4 and 5.5 microgram Chl-*a*/gram chitosan, respectively. On the other hand, the free cells released in the medium were found after 1 day and continuously grew throughout 14 day-experiment as shown in Figure 3. Burut-Archanai et al. (2013) reported that the cyanobacterium *Synechocystis* sp. PCC 6803 grew very fast under optimum light intensity with doubling time of 10-12 hours. Therefore, the leaked cells from the chitosan beads could suspend in the medium and grew rapidly. This could be observed as the medium became greenish color. Growth of *Synechocystis* inside the beads was expected to lower than free cells due to lower light transmission, lower gas and nutrient exchange inside the chitosan beads (Cohen, 2001). These results clearly suggested that the chitosan beads were not suitable for the entrapment of cyanobacteria.

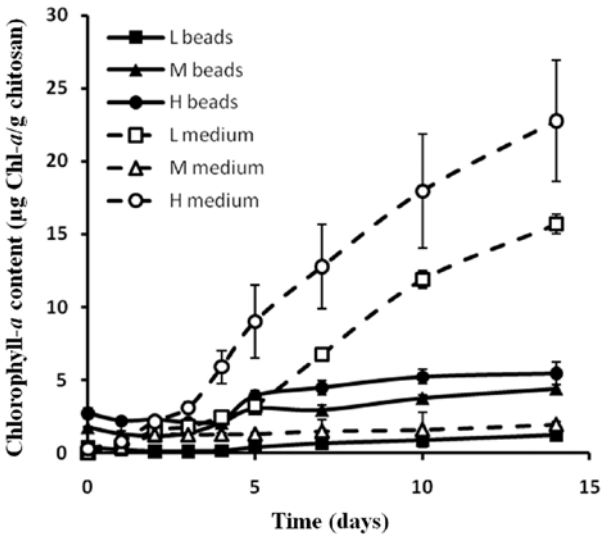

Figure 3 chlorophyll-*a* concentrations in the chitosan beads with low (L beads), medium (M beads) and high (H beads) initial cells density and in the medium (L medium, M medium, and H medium)
Source: Rojsitthisak et al. (2015)

Conclusion

Chitosan can be used as biodegradable media for immobilization of cyanobacteria, *Synechocystis* sp. PCC 6803. The suitable form of chitosan should be in flake form in which small flake size (1 millimetre) had the highest cells attachment. The immobilization efficiency depended on particle size of chitosan, pH adjustment for surface treatment on the chitosan surface and immobilization time. However, chitosan beads were not suitable for *Synechocystis* cells immobilization.

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Assoc. Prof. Thavivonge Sriburi, Ph.D.
and Saowanee Wijitkosum, Ph.D.

Biochar: Research for Community

Assoc. Prof. Thavivonge Sriburi, Ph.D. and Saowanee Wijitkosum, Ph.D. are experts in environmental management. In this issue, they share their insights in biochar research for agriculture - a technology that holds promise in ameliorating global warming.

The Start of Biochar Research

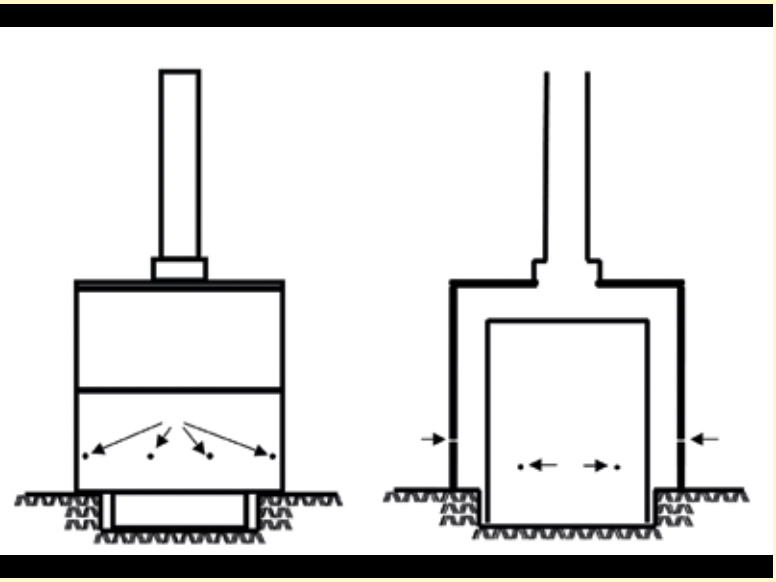
"...Leaving agricultural waste and organic matter to decompose in an open field leads to a significant increase in emissions of greenhouse gases (GHG) to the atmosphere. It is therefore crucial that we address this..."

Dr. Thavivongse: As global warming is impacting every country in the world, all countries need to take part in combating the problem. Although globally, climate change mitigation efforts have mostly focused on the industrial sector, the agriculture and transportation sectors also make a significant contribution to global emissions, and need therefore to be addressed too. In the agricultural sector, leaving crop residues and other organic matter to decompose in an open field results in significant emissions of greenhouse gases (GHG). Farmers can help reduce emissions by converting these crop residues into a form of carbon that can be incorporated into the soil, serving as a 'carbon sink' that locks the carbon in the soil.

Charcoal has been widely used in agriculture since it helps absorb water and retain soil moisture. By converting biomass such as crop residues into charcoal, which is then incorporated into the soil, plant growth can be stimulated and carbon sequestered, or locked into the soil. However, knowledge about the appropriate processes and optimal ratio of soil incorporation of charcoal is still lacking. This gap in knowledge is the reason we initiated our research to understand the best way to produce biochar with the most interesting properties, and to maximize the benefits of incorporating biochar in the soil.

The research began with the design and construction of a retort that yields laboratory grade biochar- a process that is also practical for local farmers. Once the retort design had proved successful, researchers began to produce biochar by heating biomass using a pyrolysis process that followed the FAO's standard. Charcoal produced using this pyrolysis procedure is referred to as biochar. The research team has studied the physical and

chemical properties of biochar, which offers insights into its abilities to improve soils, increase yields, and contribute to long-term carbon sequestration in the soil.



After six years of research, significant progress has been made, including in the design of a biochar retort that meets the FAO standard, identifying and distinguishing the different characteristics of biochar obtained from different biomass sources, studying the growth of different types of crops, and researching on the reduction of carbon emissions from crops achieved through soil incorporation of biochar in different ratios with soil.

Biochar Research for Agricultural Use

"...Using biochar as soil amendment will reduce the need for chemical fertilizers, resulting in a multitude of environmental benefits. It also improves quality of life for the farmers and increases their net incomes - less fertilizer means higher yields..."

Dr. Saowanee: Biochar can be used for many purposes such as carbon sequestration, soil amelioration, as an absorbent or filter for waste treatment or even as a renewable energy technology. Our research team focuses on studying two related aspects of biochar, these are climate change and increasing crop yields through soil amelioration. Our research on climate change includes studies on reducing CO_2 emissions from agricultural land. Our research on natural resources and environmental management includes techniques for production of biochar focuses on maximizing the utilization of waste biomass such as crop residues. If we can improve soil condition and nutrient availability through soil incorporation of biochar, this will reduce the need for chemical fertilizers, resulting in a multitude of environmental benefits. It also improves quality of life for the farmers and increases their net incomes - less fertilizer means higher yields.

Our past research studied several types of biomass obtained from several sources, especially crop residues from rice husks, corncobs and cassava stems. In addition, locally available biomass waste such as wood scraps were also used to produce biochar. The properties of biochar obtained from all these source materials were found to be not significantly different from laboratory-produced biochar. The low production cost and simple production process makes it easy for farmers to adopt the technology on their own land. As a result of our research, farmers can readily produce a retort for home use that can produce a large volume of biochar in each batch. Our research has led to wider adoption of biochar and biochar retort production in rural areas.

The research project began piloting in two research areas at Huay Sai Royal Development Study Centre in Cha-am and Pa-Deng Biochar Research Center (PdBRC) in Kaeng Krachan, Phetchaburi Province, in southern Thailand. The two sites face very different soil resource problems. The research, piloted concurrently, in these areas was aimed at carbon sequestration and reduction of carbon dioxide emissions, as well as increasing crops yields and improving soil conditions. The results indicate

that biochar can help with soil amelioration through improving both physical and chemical characteristics of the soil.

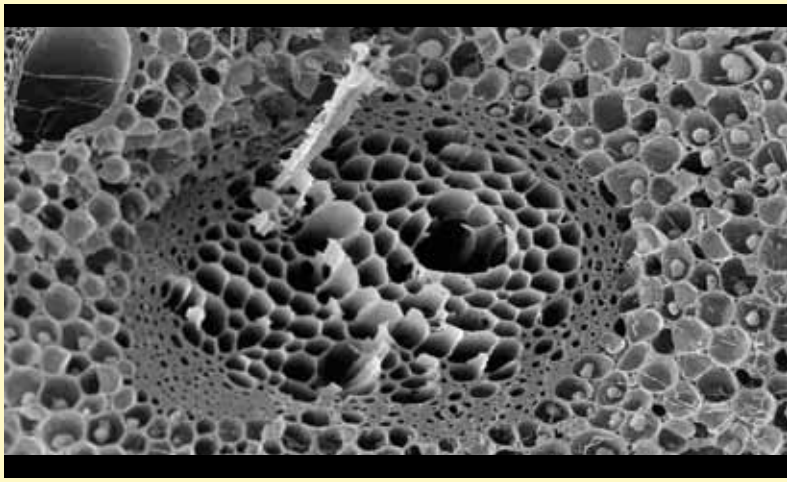
We studied the effects of biochar on increasing crop yields of several crops including rice, vegetables, and garden plants. The results indicated that biochar incorporation can lead to a statistically significant boost to crop yields, especially when applying a mixture of biochar and organic fertilizer to the fields. For example, upland rice grown in soil mixed with biochar gave a higher amount of yield per hectare, a higher amount of seeds per ear, and a higher amount of good seeds. Research conducted in soybean and field corn produced similar results. Soybeans grown in soil mixed with biochar showed better growth rate, longer roots, more ears, and heavier weight of good seeds. As for corn (maize), research from the first crop cycle indicated that corn grown in soil mixed with biochar and organic fertilizer produced higher yields than those grown in soil mixed only with organic fertilizer. This applied to all yield parameters including crop yield per hectare, as well as quality of yields including ear size, number of ears, and seed quality. When we repeated the experiment in a second cycle by growing corn on the same plots without adding additional biochar or fertilizer, we saw similar results. This showed that the effects of biochar extended beyond the first season, because of its high stability. The very large surface areas of the internal matrix of biochar improves the soil's ability to retain both water and nutrients within the internal pores of the biochar. Biochar also provides a favorable habitat for soil microflora and fauna, due to its high cation exchange capacity (CEC) and physical characteristics. Beneficial organisms such as *Azotrobacter* spp. which fix nitrogen in the soil from the air, help to retain nitrogen within the soil and also increase the amount of rhizobia in leguminous roots. Biochar's characteristics allow the material to retain nutrients and moisture and slowly release them into the soil for the crop to absorb. Such slow-release properties help reduce loss of nutrients through leaching, reducing the need for chemical fertilizers whilst maintaining crop yield and quality. Higher quality grades lead to higher farm gate prices; thus by using biochar, farmers can reduce their input costs and increase their profits.

Apart from the two aforementioned research areas in Phetchaburi, our biochar research has expanded to study its effects on saline soils in the northeastern part of the country, where soil salinity has rendered large areas of land unusable. The first research site has been established at Kham Thale So District, Nakhon Ratchasima.

Moreover, the effect of biochar incorporation on reducing greenhouse gas (GHG) emissions was studied in crops such as corn, soybean and vegetables including Chinese kale, daikon and tomatoes. The results indicated that soil incorporation of biochar could significantly reduce GHG emissions in these crops. This corresponds with research results from the international research community suggesting that biochar produced by pyrolysis could retain approximately 50% of the carbon contained in the original biomass. In contrast, without undergoing pyrolysis, the biomass naturally decomposes, releasing carbon dioxide to the atmosphere. The amount of CO_2 emitted depends on the type of biomass. Biochar's ability to retain carbon resulted in its recognition as a 'Carbon Negative Technology' that can be used to reduce GHG emissions by sequestering carbon in agricultural land.

From Research Plots to Communities

"...Past research have taught researchers the many factors to consider when introducing a new technology to the community. We need to understand problems that are specific to the locality and culture, as well as providing an understanding of how to use the technology itself. Most importantly, adoption will only happen and be sustained if we can show tangible results..."



Dr. Saowanee: So far, we have shared the results of our research conducted in the two research areas in Phetchaburi with local communities. Training sessions and workshops were offered to farmers, community leaders, and representatives from local authorities. The trainings included a workshop on constructing the pyrolysis retort, detailed information about biochar and its application, the pyrolysis process, the preparation of biomass, follow-up sessions after the biochar application, and analysis of cost-effectiveness. Feedback from participants in these training activities indicated that they are indeed interested in using biochar and are willing to use it on their own farms. Moreover, participants were enthusiastic in learning and independently trying innovative methods that could help further improve their yields.

It can be said that bringing research to communities is as important as publishing research papers in top-tier academic journals. Understanding existing problems faced by the community allows researchers to formulate relevant research questions that truly match local needs and challenges. Moreover, by presenting to the locals tangible and achievable results and giving clear, uncomplicated instructions, local people are encouraged to learn and try out new approaches themselves. By continuing to distribute research results to communities in this way, a knowledge transfer link can be established that could eventually build to become a Knowledge Management Centre for the community. Researchers can serve as facilitators to bridge the gap between research and the real world, by providing advice and guidance to local communities, contributing to their independence and self-reliance. Past research also indicates that, apart from imparting knowledge to the community, researchers themselves learned a great deal from the community.

Word soon spread about the benefits of biochar. Farmers outside the study sites contacted the research team for more information and to obtain biochar to test on their fields. Follow up sessions with these interested farmers showed significant improvement in yields. To support wider adoption, the research team has developed several publications, including cartoons, guidelines, website, and articles in academic journals, targeting various audiences.

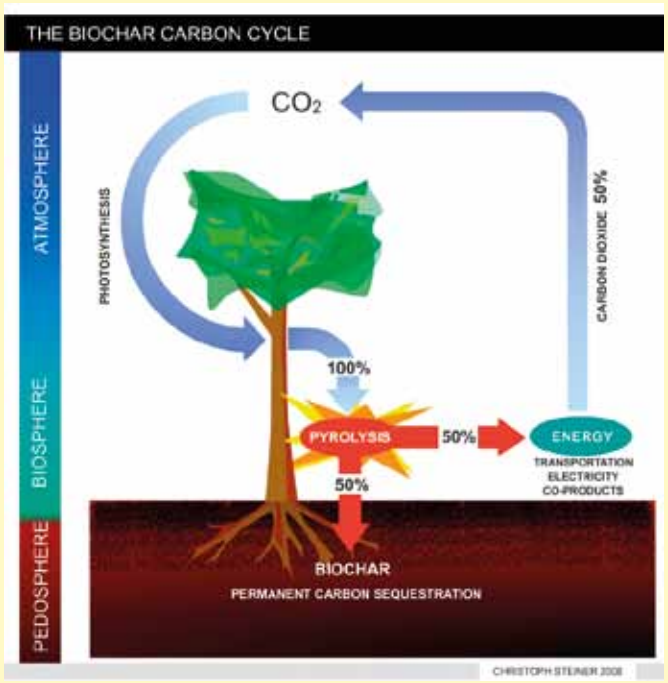
Value of biochar for carbon sequestration and reducing CO_2 emissions

"...We hope that in the near future, the wider use of biochar as a carbon sink will help reduce Thailand's GHG emissions, as is already happening in other countries..."

Dr. Thavivongse: The research team has been working on distributing knowledge on the use of biochar for carbon sequestration to local communities. We really hope that in the near future, the wider use of biochar as a carbon sink will help reduce the amount of carbon

being released to the atmosphere in Thailand as is already happening in other countries such as Australia and China.

The research team also found a gap in understanding between farmers and researchers. The majority of the farmers do understand the value and benefits of improving productivity, but do not appreciate how changing their farm practices could help mitigate climate change impacts. Therefore, researchers are doing their best to broaden this understanding among farmers, in addition to awareness of the potential of biochar to boost yields.



http://www.biochar.org

Although farmers may not fully understand the complexity of the impacts of climate change and the linkages with agriculture, they certainly notice changes in weather patterns, especially the increasingly frequent and severe droughts, changing seasons, and flooding events. Such changes have a direct effect on farming traditions and result in greater risk and yield instability.

We expect the use of biochar to increase in the future due to a growing awareness among farmers that using chemical fertilizers only helps increase yields in the short term, while causing permanent damage to the soil. They also know they have to continually increase the amount of chemical fertilizers they need to use, which leads to higher production costs. And finally, farmers are suffering more and more from the effects of climate change on crop yields. These problems are encouraging farmers to adopt different methods that could help improve yields and protect their crops from the impacts of climate change. The use of biochar in agriculture might definitely be one of these alternative methods.

How should Thailand prepare and adapt to the changes resulting from the agreement reached at COP21?

"...The public sector has to be sure that they have sufficient knowledge to pass on to farmers and be able to adapt new knowledge to suit specific needs of different agricultural areas..."

Dr Thavivongse: Thailand has promised to the global community that it will reduce the country's GHG emissions by 20-25%. The promise must be kept and mitigation measures must be launched accordingly. Considering the situation in Thailand, reducing GHG emissions from the industrial sector might be difficult since changing operation systems or production lines require very high investment. GHG emissions from Thailand's agricultural sector are ranked 3rd, following the industrial sector and transportation.

Policy and implementation measures for mitigation of GHG emissions at national level must be seriously considered and implemented. At present, the industrial

and transportation sectors are succeeding in reducing their respective emissions despite the high cost of implementation. However, reduction of emissions from these two sectors might not be sufficient to achieve the benchmark mitigation target, making it necessary to also consider targeting agricultural sector emissions. It will be crucial enforce mitigation policies and enhance understanding among farmers of climate change impacts and the consequences of inaction. The public sector has to reach out and provides knowledge to the farmers. Most importantly, government agencies must be sure that they have sufficient knowledge to impart to farmers and technologies that are proven and adaptable to location-specific needs.

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Saowanee Wijitkosum, Ph.D. received a Bachelor of Science in Environmental Health Sciences from Mahidol University, Thailand and a Master's Degree in Urban and Regional Planning (Regional Planning) from Faculty of Architecture, Chulalongkorn University, Thailand. She received her doctorate in Environmental Sciences from Chulalongkorn University, Thailand. She currently serves as Deputy Managing Director of Chula Unisearch, Chulalongkorn University and lecturer at the Environmental Research Institute (ERIC), Chulalongkorn University.

"Around us"

Assoc. Prof. Thavivongse Sriburi, Ph.D.

The Environment

http://www.ikedaquotes.org

The word *"Environment"* is broadly used, but what do we know about the exact meaning of the word in the legal sense, and how much do citizens know about their liberties and rights with regard to the environment and environmental law?

Thailand started to recognize the importance of environmental issues long ago, when environmental management was identified in the B.E. 2517 Constitution. Section 77 of the Constitution states: 'The State shall maintain the balance of environmental conditions and natural beauty as well as forests, headwaters, waterways and territorial waters'. Moreover, Section 93 stipulates that 'The State shall maintain a clean environment and dispose of hazardous wastes which cause damage to public health and safety'. However, although these two sections are fundamental to the subsequent evolution of environmental law in Thailand, the prevalent view among the public is that environmental issues are the responsibility of government, not individuals; it is still expected that it is for the government to resolve all such problems.

A later development that changed this perception was the promulgation of laws on public participation: the Official Information Act (B.E. 2540) and the rule

of the Office of the Prime Minister on Public Consultation (B.E. 2548) defined the meaning of, and process for, public participation in environmental management. However, implementation of the laws and principles of public participation have changed continuously over the years according to the prevailing social and political context. In the past, public participation was limited to a focus on voting, but has broadened in scope to encompass the notions of direct democracy, participatory democracy or self-government democracy.

In this case, public participation (PP) provides a legally-sanctioned context for citizens to participate in formulating policies and regulations, administrative procedures and decisions affecting local people. The principle of PP enshrines the need to hear voices of all relevant stakeholder groups as an integral part of the process of making environmentally significant decisions. From this law, citizens have the right to participate evaluating public or private sector projects that carry social or environmental implications.

The Enhancement and Conservation of National Environmental Quality Act (B.E. 2518) is Thailand's first specific environment law, but contained only 17 Sections. Its primary objective was to establish a National Environmental Board. However, in practice the National Environmental Board has no authority, and merely serves as the government's adviser on environmental issues. Subsequently, in the year 2521 the Act was amended by adding another 11 Sections. The total of 28 Sections cover environmental quality standards, water quality standards from factories and industrial estates, air quality and other standards, as well as stipulating rules for implementation of environmental management in Thailand.

Section 4 of the Enhancement and Conservation of National Environmental Quality Act (B.E. 2535) defines *"Environment"* as 'natural things which form the physical and biological conditions surrounding man and man-made things', while *"Environmental Quality"* means the balance of nature, being composed of animals, plants, natural resources and man-made objects which is for the benefit of subsistence of mankind and the sustenance of human-being and nature.

The same Act defines *"Environmental Quality Standards"* as the parameters for quality standards for water, air, noise and other environmental conditions which are determined as general criteria for enhancement and conservation of environmental quality.

The provisions of the law may require compliance with environmental quality standards and criteria in certain types of operations, including pollution monitoring. Other key state policies include the requirement to follow the 'Precautionary Principle', to ensure meaningful public participation at every step in project development, the establishment of environmental courts and the implementation of the 'Polluter Pays' principle'. These key policies underpin the implementation of Thailand's modern environmental law.

The Environmental Act (B.E. 2535) also defines the authorities and responsibilities of provincial and local government authorities, which are clearly in control to prevent or mitigate environmental impacts in their respective areas of jurisdiction. Of critical importance is the requirement under the Act for large projects to undergo an Environmental Impact Assessment (EIA) before approval.

Since the promulgation of the Enhancement and Conservation of National Environmental Quality Act (B.E. 2518), the Office of the National Environmental Board has emphasized preventive measures and problem solving on environmental impact solutions.

The Environmental Act (B.E. 2535) defined the EIA as an important preventive tool to control and mitigate potential environmental problems that may be caused by any proposed development project. The EIA process requires a responsible agency to oversee the process.

Despite its importance as a fundamental tool for environmental protection, EIAs suffer from some constraints, and are frequently criticized e.g. for restricting the area of project impact to be considered in their scope, and for inadequately addressing cumulative impacts, which are ill-defined under the law.

Until now, efforts to improve the Environmental Act (B.E. 2535) have been constrained by the specialized and multi-disciplinary nature of the subject. Developed countries, including some Asian countries have addressed the challenge by mandating the use of Strategic Environmental Assessment (SEA) as a decision-making tool from project start. SEA focuses on Policy, Project Implementation, Planning and Program before proceeding to undertake a specific project EIA.

Currently, SEA is used by responsible agencies such as the World Bank and the Asian Development Bank, that provide large loans to finance major

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development projects. Among these agencies, the use of SEA is a prerequisite to ensure that environmental considerations have been rigorously researched and addressed in the project design stage. The SEA process is broad-ranging and comprehensive, covering every step from policy, planning, programming and projects by collecting effects that occur to natural resources, social aspects including lifestyle, health and quality of life. The general framework for conducting SEAs is described in the following steps.

1. Policy - evaluation of the proposed project area considering government policies relating to the project, including infrastructure development.
2. Planning - evaluation of other existing and proposed developments in the area of the proposed project
3. Programming - estimate scheduling and planning policies to clarify steps and duration of the construction and operation of the development.
4. Projects - evaluate the development of specific projects in the proposed project area, covering the ongoing project and its expected benefits and impacts. The legal tool for project assessment at this stage is the Environmental Impact Assessment Report (EIA).

One example of the application of SEA in Asian countries is its focus on water resources development, including hydroelectricity projects, reservoirs, irrigation systems, factories and projects located within the watershed. According to the law, any proposed project development must first commission a SEA to evaluate all expected benefits and all impacts that may arise from the project, especially those that impact on economic, social, environmental, and people's health and the ecosystem of the watershed. Following approval, the SEA must be presented to policymakers or other responsible agency to assess on the basis that overall benefits outweigh potential future impacts and is consistent with national policy.

At present Thailand has yet to implement SEA as a policy tool; however, it will undoubtedly be essential to do so for the country's future development. In the meantime, inadequate checks and balances allow projects to proceed despite strong local opposition, and despite their major social environmental, social and public health costs. Local communities and the public are forced to accept such projects. The government needs to act on an urgent basis to establish a legally mandated requirement for SEA, and to bolster the public participation process to reduce conflicts between people in areas with project owners and operators, at both national and local levels.

http://www.worldbank.org/environment/

Paradigm for an Urban Sustainable

Green Area Network

Development happens fast in Bangkok. Rapid population growth and economic advancement have driven an ongoing boom in construction of large business buildings and residential housing. This economic success has been achieved by sacrificing open spaces and green spaces within the city, and at the expense of the environment and quality of life for the city's 10 million citizens. Air and water pollution, congestion and rising urban temperatures are just some of the growing environmental impacts facing Bangkok and most major-cities in Asia and elsewhere. It is therefore imperative that we find innovative approaches to overcome these problems, protect our environment and improve the quality of urbanites.

A first priority would be to expand the city's green area and connect them in a contiguous urban network spanning the metropolis. By creating new habitats and refuges, such a network would help restore the ecological balance, whilst helping to reduce environmental problems such as congestion and air pollution, and creating a vibrant, aesthetic landscape with beautiful trees to shade the city and provide recreation and respite from the rat-race. Such spaces for recreation and exercise will greatly improve quality of life for the general public.

The paradigm for an urban sustainable green area focuses on the development planning of green space by using the areas along canals in the city centre, areas along main roads, and existing parks. The paradigm requires an alignment and integration of plans for social, environmental and economic development within the urban space, and offers an approach to urban landscape management plan based on a network of green areas across the entire city. We use the paradigm to define the spatial boundaries of an *"urban sustainable green area"* divided into 3 parts, as follows:

- An urban sustainable green area within Bangkok city centre.
- Green main road areas, shady streets for pedestrians and cyclists, including landscape improvements to add green areas to facilitate pedestrian traffic and expand the network of cycle tracks.
- City parks and landscapes to provide recreational and amenity value to Bangkok residents. These parks would be linked to each other via *"green corridors"*.

The paradigm of the urban sustainable green landscape emerges as a multi-disciplinary approach grounded in number of basic concepts and theories. These are as follows:

- Analysis of land utilization, including the terms of land utilization.
- Landscape design that affects the environment according to citizens using and benefit of the living and the beauty that can result in better quality of life.
- Urban redevelopment based on analysis of problems and potential of the city's physical factors, to enable detailed design and appropriate construction.
- Urban ecology, which refers to the relationships and inter-dependencies among the main components of an urban system, its physical location and built environment.
- Environmental design is the study of the relationship between applications, conditions of the area, design and natural environment, as a basis for selecting technologies and approaches that are appropriate and optimize to the specific environmental context.
- Road landscape design, comprising four main criteria: 1) size and pedestrian areas, 2) standard width and companionway, 3) appropriate cycle path or area, and 4) components of the street landscape.
- Urban transportation planning, which ensures that system design is consistent with the existing and forecast urban traffic system.
- Plants for landscaping are selected for their suitability to the urban environment, especially in terms of ease of maintenance; low water demand, and minimal requirements for resources and labour.
- Maintenance of the city's greenery, especially large trees in the city, as a resource to create a better urban environment.

Researchers have brought together these diverse concepts and ideas to create a new paradigm for an urban sustainable green area, and worked with related agencies to develop a practical plan to implement it. This required collection and analysis of essential basic data relating to the physical, socio-cultural and economic environments, ongoing projects, and detailed land use analysis and scenario building in order to identify ideal potential areas to create urban sustainable green area networks.

The process involved extensive consultation with all concerned stakeholders in order to ensure that the final plan was relevant to needs, practical and acceptable to all affected parties. Views and opinions of communities, companies and government agencies were sought through a rigorous public participation process, to provide inputs at all stages, from defining the conceptual framework to preliminary planning and detailed design, management and maintenance plan. Participation and consent of local communities, along with cooperation between landowners and relevant authorities, are vital to successful and sustainable greening of Bangkok's urban space.

Chulalongkorn University Executive Program "Bhumipalung Phandin" (BPP) congratulates Air Chief Marshal Prachin Chantong on the occasion of his appointment as Deputy Prime Minister

Graduates of the ***"Bhumipalung Phandin"*** (BPP) Chulalongkorn University Executive Program recently joined hands to offer their congratulations to Air Chief Marshal Prachin Chantong, an alumni of the 1st generation of the BPP Program, on his appointment as Deputy Prime Minister.

Attending the event to represent the BPP Executive Program were Assoc. Prof. Gr. Cpt. Permyot Kosolbhand, M.D., Vice President for Property Management of Chulalongkorn University and Assoc. Prof. Thavivongse Sriburi, Ph.D., Managing Director of Chula Unisearch (BPP alumni from the 1st generation). Assoc. Prof. Voranop Viyakarn, Ph.D. (BPP 2nd generation), Prof. Mongkol Techakumphu, DVM (BPP 3rd generation), and Supichai Tangjaitrong, Ph.D. (BPP 4th generation). Also present were Assoc. Prof. Sunait Chutintaranond, Ph.D. (Dean of Chulalongkorn University Graduate School and Program Director of Academic Affairs of BPP), Saowanee Wijitkosum, Ph.D. (Deputy Managing Director, Chula Unisearch) and Sornnate Areesophonpichet, Ph.D. (Manager of Coordinate Academic and Industry Collaboration Office).

As part of his responsibilities as Deputy Prime Minister, Air Chief Marshal Prachin Chantong will oversee the work of the Ministry of Information and Communication Technology, Ministry of Energy, Ministry of Education and the National Research Council of Thailand, as well as exchange ideas on the development of academic and research interests in developing countries at Government House.

Stakeholder consultation to hear opinions on "The 3rd development of facilities and optimization services in the transport sector for disabled and elderly people"

The Office of Transport and Traffic Policy and Planning (OTP) and **Chula Unisearch** held a joint seminar to raise awareness and listen to stakeholder views on **"The 3rd development of facilities and optimization services in the transport sector for disabled and elderly"**. In conjunction with the seminar, an exhibition was also staged under the concept of **"OTP Transport for All"**. The objectives of the seminar were to promote increased access to public transport for the disabled and elderly access improves safely and equality in public facilities. It was a great honour to have Mr. Arkhom Termpittayapaisith, Minister of Ministry of Transport, presiding over the seminar, held at the OTP.

The seminar attracted 120 participants from a range of concerned agencies, including the National Office for Empowerment of Persons with Disabilities (NEP), academic institutions, professional organizations for textiles and design, as well as related Government agencies. OTP presented project summaries covering three main areas: 1) A strategic plan for development of Bangkok's public transport system for the benefit of all, with special emphasis on the special needs of the disabled and elderly; 2) A prototype for five categories of transportation services; and 3) A guide to assist the elderly and disabled in each transportation category, including a translation and sign language manual guide. These have already been sent to Cabinet for consideration.

Interested parties can download all project summaries and other details at www.OTPTransportForAll.com or Facebook: OTPTransportForAll.

"Bhumipalung Sangitaphivat" Fundraising Concert in honour of Her Royal Highness Princess Maha Chakri Sirindhorn Supporting construction of a new building at Queen Savang Vadhana Memorial Hospital.

On the auspicious occasion of the 60th birthday anniversary of HRH Princess Maha Chakri Sirindhorn, **Chula Unisearch**, on behalf of Bhumipalung Phandin Club (BPP Club) and Chulalongkorn University, organized a ***"Bhumipalung Sangitaphivat"*** Fundraising Concert held on Tuesday 13 October, 2015 at the Chulalongkorn University Auditorium. Honoured guests were welcomed by Prof. Pirom Kamolratanakul, M.D., President of Chulalongkorn University, which was attended by Privy Councillor H.E. M.R. Thepkamol Devakula as Guest of Honour, with H.E. Air Chief Marshal Chalit Pukbhasuk presiding over the event.

The objective of the concert was to raise funds to be donated to HRH Princess Maha Chakri Sirindhorn in support of the Thailand Red Cross Society. The funds will be used for much-needed new hospital building at the Queen Savang Vadhana Memorial Hospital at Sriracha, on the initiative of HRH Princess Maha Chakri SIrindhorn to commemorate the 150th anniversary of Queen Savang Vadhana. The hospital was built over 112 years ago and currently serves over 1 million patients per year. To cope with a continuing increase in patient numbers, improvements are needed to part of the hospital buildings, the healthcare system as well as modern tools and medical devices needed to provide patients with world-class services adequately and effectively.

The ***"Bhumipalung Sangitaphivat"*** Fundraising Concert featured the Suanplu Chorus, the Royal Thai Navy Music Division, and leading nationally famous artists. The audience was also entertained by performances of flute and violin instrumentals by two leading national artists from the People's Republic of China, together with Supreme Artists of Thailand, in a fitting symbol of the warmth of the relations between the two countries.

The BPP Club was formed by alumni of the ***"Bhumipalung Phandin"*** (BPP) Executive Program conducted by Chulalongkorn University. The course aims to encourage senior level executives participating in the course to pledge to continue His Majesty the King's Royal vision and mission by creating benefits for society and the nation, as well as maintenance of the three main institutions- the nation, religions and the Monarchy. The BPP Club was established to promote and carry out activities that support these goals and contribute as a pillar of society, together driving national prosperity under the guidance of His Majesty the King.

Stage hearing "The Issue of Legal Assistance for Foreign Visitors"

The Legal Affairs Division, Department of Tourism, Ministry of Tourism and Sports, together with **Chula Unisearch**, held a meeting on the topic: ***"The Issue of Legal Assistance for Foreign Visitors"*** at the Surakiart Sathirathai meeting room, Thebtaravadee Building, Faculty of Law, Chulalongkorn University. It was a great honour to have Mr. Suthum Dechdi, Director of the Bureau of Tourism Business and Guide Registration presiding over the meeting, which attracted a total of 120 representatives from both public and private sectors involved in providing assistance and protection for tourists in Thailand, as well as teachers and students from Faculty of Law, Faculty of Hotel and Tourism Management, Faculty of Tourism Industry and Hospitality, and tour guides.

Chula Unisearch joins "Research for Community" exhibition

Assoc. Prof. Thavivongse Sriburi, Ph.D., Managing Director of Chula Unisearch and Saowanee Wijitkosum, Ph.D., Deputy Managing Director, Chula Unisearch were invited to present their research findings for the community on the topic **"Using Biochar for soil amelioration and increasing crop yield for food security and sustainable agriculture"**. The presentation formed part of the Research for Community Exhibition organized by the National Research Council of Thailand (NRCT) at NRCT building No.1 on Wednesday 9 December, 2015. The exhibition aimed to showcase Thailand's research potential in integrating available knowledge, research, innovation and technology to support local communities and society, and in effectively addressing problems and delivering new solutions according to government policies. The event included a press conference to announce the signing of a Memorandum of Cooperation between NRCT and 20 executives of higher education institutes in Thailand. The exhibition showcased findings of community research with practical application for local communities. Deputy Prime Minister Air Chief Marshal Prachin Chantong presided over the opening of the event.

The research project **"Using Biochar for soil amelioration and increasing crop yield for food security and sustainable agriculture"** received financial support from the National Research Council of Thailand under NRCT's knowledge management, innovation and technology transfer programme for 2014. The study was part of a collaborative research between researchers at **Chula Unisearch** and the Environmental Research Institute, Chulalongkorn University, who together conducted research into biochar, including the design and construction of a patented Controlled Temperature Biochar Retort for Slow Pyrolysis Process incinerator. The biochar research helped to improve soil quality and agricultural productivity in the area of Huay Sai Royal Development Study Centre and Pa Deng Sub-district, Kaeng Krachan, Phetchaburi since 2011, by transferring knowledge and technology directly to local communities and farmers, government agencies and local government. The project contributed to the strength of the community, local food security and sustainable agricultural development in the project area that would serve as a model of success to be replicated in other areas around the country.

Department of City Planning and Chula Unisearch organize public hearing on "The 4th Paradigm for Urban Sustainable Green Area"

The Department of City Planning, Bangkok Metropolitan Administrator together with **Chula Unisearch** recently organized a public hearing on ***"The 4th Paradigm for Urban Sustainable Green Area"***. The event was held on Wednesday 4 November, 2015 at Sasa International House, Chulalongkorn University. Ms. Panyapas Noppapan, Deputy Director of the Department of City Planning presided over the opening ceremony of the event, which was attended by representatives from a range of public and private sector organizations, educational institutions and the general public. Participants presented their views and ideas to develop a pilot project that will maximize public benefit and minimize social and environmental impacts.

Assist. Prof. Pongsak Vadhanasindhu, Ph.D., Former Dean of the Faculty of Architecture, presented details of the project's progress to participants, including an overview of the actual roads areas, canals and parks in Bangkok, and a report on progress in environment development in the pilot area in Sathorn Road. He also reported on plans for improvements in pedestrian traffic system connections and public transport system efficiency.

The conceptual framework for the operation comprises seven components: Connection, Green Infrastructure Services, Environmental Benefits, Attractive City, Possibility, Conservation Culture and Private Sector Participation. Links are create between each green space to form a contiguous network; public routes roads and canals will also be connected to this network of green spaces- ***"the city as a park"***.

The project defines the following vision for green area network development in Bangkok: ***"Bangkok's Green Infrastructure, Shady Street, Environmental Restoration, Strong Community"***. Supporting this vision are three strategies as follows:

1) Bangkok's green infrastructure promotes the work of the traffic system to enhance existing transportation and links public transport systems with pedestrian ways and bicycle lanes across the city.

2) Bangkok's green community: by reaching out to engage communities, local residents have the opportunity to participate in shaping the development of green spaces within their own community, and in creating more green spaces throughout Bangkok.

3) Bangkok's green infrastructure will help relieve environmental impacts such as the Urban Heat Island (UHI) effect, flooding, air and water pollution, and improve quality of life.

Special Ceremony to Commemorate King Rama VI Memorial Day

Representatives from the Executive's Board of **Chula Unisearch**, Saowanee Wijitkosum, Ph.D. and Assoc. Prof. Suchana Chavanich, Ph.D., Deputy Managing Director, Chula Unisearch, joined a special ceremony to pay homage on King Rama VI Memorial Day by laying garlands at the King Rama V and King Rama VI statues in front of the Chulalongkorn University Auditorium and the Statue of King Rama VI in Lumpini Park.

Blessing His majesty the King Bhumibol Adulyadej on the auspicious occasion of his 88th birthday

Executives and staff of **Chula Unisearch** together expressed respect and unity by wearing yellow shirts and blouses throughout December, 2015 on the auspicious occasion of the 88th birthday of His Majesty King Bhumibol Adulyadej's on Saturday 5 December, 2015. **Chula Unisearch** staff are united in their gratitude for the benevolence of His Majesty's royal duties, performed throughout for the benefit and happiness of Thailand's people. On the same occasion, **Chula Unisearch** contributed to the historic event ***"Bike for Dad"*** by providing drinking water and snacks for Chulalongkorn University students, staff and other who joined the activities in front of Chamchuri Square.

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